PUBLISHED EVERY SATURDAY BY
THE W. J. JOHNSTON COMPANY, Limited,
167-177 TIMES BUILDING, NEW YORK.
Telephone Call: Cortlandt 924. Cable Address: "Electrical," New York

New England Office, 28 Hathaway Building, Boston.
Western Office, 465 The Rookery, Chicago.
Philadelphia Office, 927 Chestnut Street.

SUBSCRIPTION, IN ADVANCE, ONE YEAR $3.
(Including Postage in the U. S., Canada or Mexico.)

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VOL. XIX. NEW YORK, MARCH 5, 1892. NO. 10.

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Size and Efficiency of Transformers. MR. STILLWELL'S paper on this often discussed topic is worthy of careful reading for its very practical presentation of the case. When the alternating system was originally introduced it was the practice to use many small converters, and it was even proposed to use individual converters for each lamp. With the growth of the business larger sizes of converters came into use, and it was very soon found that efficiency was much higher, to say nothing of the smaller relative cost. For example, as stated by Mr. Stillwell, the efficiency of a five-lamp converter may be somewhere near 90 per cent., in a 100-light converter the efficiency may rise to over 96 per cent. In most cases greater losses in secondary wiring with the larger converter still leave considerable margin in its favor, and the initial cost is very decidedly less. A considerable portion of the incandescent lighting in New York is carried on, as we recently had occasion to state, with banked converters; a considerable number, sometimes 30 or 40, running in parallel. It is unnecessary to state that such a bank is less efficient than if it were replaced by a single large converter or composed of a few of intermediate size. In fact one might well apply the same rule to converters that holds for generators in central stations. Large machines are an advantage up to the point where the number of units becomes so few that the disabling of one of them will seriously overload the others.

The Electric Light Convention. TAKEN altogether, we may score down the Fifteenth Convention of the National Electric Light Association as a thorough success. It was, first, last and always, businesslike, and the papers and discussions awakened great interest among the members. Of course there was more or less of the by-play always found at conventions. Social functions were anything but numerous, although the absence of minor entertainments was more than made up by the splendid banquet tendered to the association. Exhibits were principally of the vest pocket character. Of course some of the regular attachés of the association were with us as usual; the chap who confidentially shows you "the greatest discovery of the age"; he of the multiplicity of polychromic circulars, and the fellow who has nothing to say and unhesitatingly says it. But altogether there was less that could have well have been dispensed with than has generally been the case. The reception accorded to the association by the citizens of Buffalo was most cordial and gratifying, and was fully appreciated by every one present. Hotel accommodations were better than usual, and the delegates went away with the pleasantest impressions of what had been their temporary home. Particularly is the association to be congratulated on the excellent choice of officers for the ensuing year, which gives ample security for the efficient character of the next convention, which is to be held in St. Louis, the home of President Ayer, a year from now. The summer convention was wisely dispensed with. It had become burdensome, and there has always been considerable difficulty in finding a convenient and suitable place for the meeting. With one convention a year and that devoted to active business the National Electric Light Association ought to enter on an era of increased and continuous prosperity.

Underground Railway Construction. ONE of the most interesting papers read at the Buffalo Convention was that by Mr. J. B. Craven, of Buffalo, describing the underground construction used by the Buffalo Railway Company for its feeder lines. While the methods of ordinary underground work have been pretty thoroughly worked out, when electric railway lines are thus placed additional special difficulties have to be met, for the railway system is always grounded, and consequently there is throughout the feeder system a difference of potential between the cable and the earth amounting to 500 or more volts, so that the establishment of continuous insulation becomes rather more difficult than under ordinary circumstances. In addition there are some very heavy strains from overload put upon the cable, so that the severity of the service is enhanced. Lightning protection in the underground mains is also a serious matter, for in case the trolley wire should be struck even the underground feeder might not be exempt. The general system employed in Buffalo is to use a high grade of cable, and to depend on the conduits merely for mechanical protection. The conduits themselves are laid in cement 30 inches below the surface of the street, and are crowned in the centre, so that water will drain off to the manholes, which are connected with the sewer system. To keep out injurious gases a blower is attached to the system of ducts at the station, thus ventilating the entire system. Manholes are placed every 400 feet. The cables are lead covered, provided with an external fibrous jacket saturated with pitch to protect the cables while they are being drawn into the ducts. Although there are 45 miles of cable, some individual lines being eight miles in length, the lowest resistance for any one feeder is 120 megohms. The system has been six months in use, and thus far has worked admirably. It is an interesting experiment, the results of which will be watched with a great deal of interest by street railway managers, for there are situations where the municipal authorities compel feeders to be placed underground. It is expensive, of course, but ought to be capable of giving entirely satisfactory service. With the system properly laid out overhead feeders are quite unobjectionable, but occasionally the authorities may force them underground, and where such is the case the Buffalo construction is worth a careful examination as a model.

The New York Underground System. ONE of the most intensely practical papers read at the Buffalo Convention was that by Mr. E. A. Leslie on the operation of high tension circuits underground as instanced by the experience in New York. The paper may aptly be divided into two sections, one dealing with the physical side of the question and the other with its financial aspect. From the former standpoint underground service may be pronounced a success, and the ease with which high insulation is established and kept up in the New York conduits will probably be a surprise to most of our readers. The conduit itself plays no part in the insulation, simply serving to protect the cables from mechanical injury, and really the most serious difficulties that are met are those involved in the making of suitable joints. As a matter of fact the underground service can be kept up to the very highest point of efficiency with probably a little more cost for maintenance than if the wires were overhead and considerable less liability to serious interruption. Eternal vigilance is the price of this security, however. From the financial point of view there is little than can be said for the underground system. To begin with, the extortions of the subway company in New York City are of a character to discourage the growth of electric lighting. To charge for a single year's rent from 30 to 50 per cent. of the cost of ducts rented is to limit the extension of electric lighting, and to render necessary prices that are in themselves an additional hindrance to the extension of business. People who grumble at the rates charged for electric lights in New York have no realizing sense of the great expense of the service. When single house connections sometimes cost over $200, and the rent of ducts alone amounts to $1,000 a mile, it is impossible to furnish lights for the cheap rates that prevail when overhead construction can be freely used. Furthermore, there are parts of the city where they cannot be carried at all at present, owing to the lack of subway facilities, and still others where it is only possible to establish a service at a prohibitive cost. Were the electric lighting companies given permission to build their own conduits, as gas companies are permitted to lay their own mains, much better and cheaper work might be done, but as it is the financial outlook is not encouraging. It has been proved to be a comparatively easy matter to put wires underground and keep them there with entire success; the simple matter of cost is, however, enough to hinder or forbid electric lighting even in many parts of New York, and in less densely populated cities to prevent the general distribution of electricity.

Transmission of Power. ONE of the most profitable sessions of the National Electric Light Association was that devoted to the discussion of the electrical transmission of power. It was aptly initiated by Mr. Carl Hering's paper on the general problem as illustrated by the Lauffen-Frankfort plant, which has made such a sensation the past summer. There seems just now to be a wide diversity of opinion as to the methods that should be pursued in this long distance work that is likely to become so prominent a factor of electrical engineering in the very near future. Continuous currents, the synchronous alternating system, the two and three phase rotary field systems, all have enthusiastic advocates equipped with divers reasons for the superiority of their respective pet methods. The fine results obtained by the three phase transmission from Lauffen to Frankfort have just at present raised that apparatus to the rank of a first-class electrical fad, and not without reason, for so excellent were the results obtained, on the whole, as to lead to general confidence in the apparatus by which they were obtained. Nevertheless, a point which we wish to make here is that in the transmission of power to long distances we have very much to learn. High tension continuous current apparatus, several units running in series, has been tried only in a single isolated case, and with a moderate amount of success. The synchronous alternating method has been tried with excellent results in a single American plant, but over a short distance and under circumstances especially favorable to the case. The two phase rotary field has not been tried upon a large scale at all, and the three-phase system only, as before mentioned, at Frankfort, and in connection with this it may justly be remarked that the false currents due to static capacity of the line show in some of the Lauffen experiments to a rather discouraging amount. What we most need now in the way of practical information is a series of experiments on these various proposed methods, such as can be tried, however, in the shops of any large company. Concerning the direct current proposals we wish to know the total efficiency, and the difficulties, perhaps serious, that may be met in the care of high tension commutators carrying comparatively large currents. From all the alternating systems we desire to know the actual efficiency of transmission, and the nature and magnitude of the difficulties produced by static capacity of the line. In case, as Prof. Elihu Thomson very pertinently suggested, the conductors are put underground in iron pipes and insulated with oil, this capacity must be very considerable, and even with overhead lines the experience at Lauffen has shown this result. To be sure the effect of capacity will be partly annulled by the self-induction of the apparatus, but to what extent is this practicable, and in any case is the capacity of the plant for useful output likely to be seriously cut down by the capacity of the line? Regarding the synchronous system, it is very desirable to know whether a convenient, cheap and simple starting apparatus is available, and whether, in addition, motors such as those devised by Mr. Stanley and described in his paper at the convention will meet the requirements for power distribution after the current has reached its destination. Regarding the two and three phase rotary field methods, the working efficiency of the motors must be accurately determined and the question of running many motors in parallel —concerning which some doubts have been expressed —must be definitely settled. The practicability of very high tension alternate current dynamos feeding the line directly instead of by step-up transformers must be thoroughly gone into. Meanwhile plants of more or less importance will have to be built with such apparatus as can now be commanded. The electrical transmission of energy is just now beginning to develop, and it will not do to be too hasty in deciding off-hand in favor of one method over another. We have for guidance only a few isolated and uncertain experiments, and while the success of long distance transmission of power should never for a moment be doubted, the particular methods which will lead to it are as yet by no means definitely settled. Steady and persistent experimental work is necessary, and meantime the problems that actually present themselves must in most cases be solved by methods which have been thoroughly tried, for a single unsuccessful commercial experiment would do an untold amount of damage in the progress of the art.

Latest Foreign Electrical News.

(By Cable from Our Own Correspondent.)

London, Feb. 29, 1892.—On Thursday last a notable event occurred in the House of Lords, for Sir William Thomson, whose elevation to the peerage I mentioned in a dispatch some weeks ago, took his seat in the House, being very appropriately introduced by his friend and fellow-worker, Lord Rayleigh. He assumes the peerage under the title of Lord Kelvin.

Technical education is continually gaining increased facilities, the latest addition to the educational forces being the William Siemens Electrical Engineering Laboratory, of Kings College, London, which was formally opened by Sir William Thomson on Feb. 19.

Several legal and legislative skirmishes are on hand just now. On Tuesday an action on the Lane Fox distribution patent was begun. It will be remembered that Lane Fox holds somewhat the same relation to the incandescent light in this country that Edison does in America, and has strong claims for priority in the entire matter. His rights in the matter of electrical distribution, however, are regarded as somewhat doubtful.

A special meeting of the London Chamber of Commerce, convened on Monday last, decided to petition the government to introduce a bill dealing with the telephone question somewhat on the lines of the electric lighting acts. Since the expiration of fundamental patents the question of telephone corporations has been continually before the public, and it seems time for some definite legislative action.

The Cambridge municipality, whose actions with reference to the establishment of an electric light plant I have chronicled from time to time, have finally decided to abandon the idea after giving it long consideration.

The Buffalo Convention.

The city of Buffalo began to take on a crimson hue at or about midnight on Monday, Feb. 22, when the contents of the "electric special" were let loose upon the Hotel Iroquois. An active vanguard had been learning the ropes during the preceding 48 hours, and nearly every train on on Tuesday and Wednesday brought additional delegates to attend the fifteenth convention of the National Electric Light Association.

The nominal hour of assembling for the first session was 10 o'clock Tuesday morning, but as many of the delegates were at breakfast actual business was postponed until an hour later. The sessions were held in the fine lecture room of the Buffalo Library Building, and to the delegates assembled the Hon. Charles F. Bishop, Mayor of Buffalo, made a very appropriate address of welcome, initiating what proved to be as cordial a reception as the association has ever been greeted with. He extended to them the freedom of the city, its environs and suburbs. President Huntley then made his address, discussing the commercial aspects of electric lighting from the standpoints of the producers, of which a large part of his audience was made, and pointing out the absolute necessity of good business management, showing that the actual cost of power was a comparatively small portion of the total running expenses of an electric light plant, so that it must be regarded as a business institution to be conducted in the same systematic and careful way as a great manufactory.

The morning session was concluded by Mr. M. J. Francisco, of Rutland, reading the report of the Committee on Underground Conduits and Conductors. Mr. Francisco summarized the work that had been done in this particular branch of electricity, but took a somewhat discouraging view of the underground situation. As might have been expected the discussion of this subject was lively, and brought out a good deal of interesting personal experience from the members of the association. The general opinion seemed to be that while underground circuits are thoroughly practicable and will give good service, the cost is in very many cases quite prohibitive. Mr. C. H. Wilmerding, Mr. M. J. Perry and William Stanley, Jr., took the principal part in this profitable debate.

The afternoon session brought to the front Mr. L. B. Stillwell, of Pittsburgh, who discussed the "Relation of Size and Efficiency in Transformers"—a subject with which, from his long experience in the Westinghouse company, he was thoroughly familiar. His discussion was eminently practical, although it did not altogether meet the views of some of his audience. Prof. Elihu Thomson and Mr. William Stanley, Jr., took a prominent part in the discussion of the paper and contributed to it some important and interesting matter, especially with reference to the effect of heating of transformers and its relation to efficiency.

Next in order came another committee report, this time on the subject of Safe Wiring, from Mr. M. D. Law. This subject had been gone over pretty thoroughly at the previous convention, and only certain mooted questions which had been referred back to the committee were included in this particular report. The discussion was somewhat heated, especially when the question of interior conduits was brought up, but finally closed after several corrections had been made in the safe wiring rules adopted at the Montreal convention. The rules as finally adopted read as follows:

Inside Wiring.—Art. 7. Inside conductors must not be laid in plaster, cement, or similar finish without an exterior metallic protection.

Special Wiring.—In rooms where inflammable gases exist the incandescent lamp and socket must be inclosed in a vapor-tight globe. This is not understood to include rooms where illuminating gases are used in the ordinary manner.

Art. 2. The word "water-proof" change to "moisture-proof," so that the article will read: Provided with a durable moisture-proof covering.

Interior Conduits.—Art. 2. Interior conduits must not be of such material or construction that will be injured by plaster or cement or other surrounding material, or that the insulation of the conductor will be ultimately injured or destroyed by the elements.

A report from the committee on the World's Columbian Exposition from Mr. B. E. Sunny was postponed to await the coming of Prof. Elisha Gray, who would present matters connected with the Exposition to the association The session terminated with a paper from Mr. D. Ashworth on "The Allied Powers," meaning, of course, steam and electricity. It was of a general nature, describing the development of these two powerful agents and their effect on modern civilization and industry.

The evening session was given up to the electrical transmission of power, and the room was densely packed with an appreciative and interested audience. The principal feature of the evening was Mr. Carl Hering's paper on "The Transmission of Power," dealing with various methods that have been employed for the purpose, and especially referring to the operation of the Lauffen-Frankfort transmission of power plant as he had seen it in operation at Frankfort. The description of this was illustrated with a number of lantern slides, and was a most interesting contribution to a department of knowledge with which few engineers at present are familiar. As might have been expected it brought out a protracted and profitable discussion. Prof. Elihu Thomson expressed himself as an enthusiastic believer in the future of the transmission of power, and spoke appreciatively of the excellent results that might be obtained from the three-phase system, especially due to its great adaptability for various purposes. He had no fear of employing enormous potentials to save copper in the line work; he believed that considerations of safety and ultimate economy pointed to the use of underground conductors for this purpose; he suggested that iron pipes filled with oil and containing the high tension mains be used—a system which he has worked out in considerable detail. Mr. H. Ward Leonard took the view that distribution to consumers is best effected by means of continuous currents in the present state of the art, and consequently recommended the use of motor dynamos to obtain the working current, the motors to be driven synchronously by alternating generators at the extreme end of the line. Mr. L. B. Stillwell, who next took up the discussion, was also a firm believer in the possibilities of the synchronous motor, although he held that the two-phase system might be quite as efficient as that used at Lauffen. He gave an interesting account of the only synchronous alternating plant in the country, that used for mining purposes at Telluride, Colo. Mr. C. S. Bradley was outspoken in favor of the three-phase system with which he was one of the very earliest workers, and held that better results could be obtained by it than by any alternating motor system as yet brought out. Dr. Louis Bell next took a hand in the discussion, looking at the matter not so much from the theoretical standpoint as from that of the practical engineer who had to meet at short notice problems of great industrial importance. Dr. Bell believed that the best working results would be obtained by not tying up rigidly to any one system, but putting in the best obtainable apparatus of such kind as seemed best fitted to the problem, using three phase, two phase or synchronous alternating systems, or even direct currents. Mr. William Stanley, Jr., who is one of the very few men who have had some practical experience with very high potentials, gave some description of the working of a 15,000-volt experimental circuit which he has had in operation in Pittsfield. Like Prof. Thomson he is a believer in very high voltages, and thought that for a problem such as the transmission of power from Niagara Falls to Buffalo not less than 100,000 volts should be used, using the iron pipes and oil insulation suggested by Prof. Thomson.

Throughout a good deal of attention was paid to the proposed Niagara Falls-Buffalo transmission of power plant, thus giving special local interest to what was in general a valuable discussion of this very important matter.

Wednesday morning the early part of the session was occupied by a paper from Mr. C. A. Schieren, he of the perforated belt, giving the history of the belt from the beginning of the operation of tanning until the completed article is ready to be put into service. The discussion of this topic was comparatively brief, Mr. Schieren confining himself to answering a few pertinent and impertinent questions on the subject.

The event of the morning was a paper by Mr. William Stanley, Jr., on alternating current motors. This opened with a general discussion of the problems involved in the construction of a successful motor for work on alternating circuits, and the author reviewed several of the plans that had been proposed to this end. Peculiarly interesting, however, to the meeting was the description of the very ingenious type of motor devised by Mr. Kelly and Mr. Stanley, in which the interposition of a condenser was employed to neutralize the self-induction of the motor that has hitherto proved a serious difficulty in constructing such machines. By this device it is possible to operate a shunt or series wound motor much like those with which we are familiar in direct current work, on ordinary alternating illuminating circuits, so putting the apparatus within reach of our present central station service. The subject led to a discussion that was all too brief. Mr. L. B. Stillwell gave some account of the recent developments of the Tesla motor, and expressed himself, as on the preceding evening, as favoring this type rather than the three-phase system that is occupying so great a share of the attention of electricians to-day. Mr. Stanley, in replying, also expressed himself as believing in two-phase as against multiphase motors.

Prof. Elisha Gray, of Chicago, was introduced, at the close of this discussion, and explained the plans for the electrical Congress of the World's Columbian Exposition. These were received with considerable interest, but there was evident regret that the association could not take part as an organization but only as an aggregation of individuals. As the propositions made by Prof. Gray looked entirely to the organization of a homogeneous congress in which no electrical body would be allowed to take part as such, the most that could be done was to refer the matter to the association. A letter from Mr. B. E. Sunny was also read, explaining the present state of the preparations for the electrical congress.

The resolutions of regret on the death of Mr. George Worthington, that had been prepared by a committee appointed for that purpose, were then read. They were a feeling tribute to the memory of one who had been from the start an earnest friend of the association, and were directed to be suitably engrossed and a copy presented to the family of the late Mr. Worthington.

The afternoon was devoted to a trip to Niagara with the special object of inspecting the work that has been accomplished by the Cataract Construction Company. A special train was furnished and a large majority of the delegates proceeded to the Falls and viewed with great interest the great engineering work that is to utilize the power of Niagara for industrial purposes. The members were most hospitably entertained, and many repaired to the interesting water-power station of the Brush company, where a lunch was served, and the members had a chance to inspect the rope driving apparatus of the station, which, to most of them, was both new and exceedingly interesting. This very agreeable excursion was largely due to the energies of Mr. Benjamin Rhodes, manager of the Brush Electric Light Company, who planned the trip and made all the arrangements.

The evening session of Wednesday opened with a paper by Mr. M. C. Sullivan on switchboards, discussing the requirements that should be fulfilled, and giving suggestions as to the best material and arrangement to be used. In the discussion, in which Messrs. Scott, Robinson and Leslie took part, a good many interesting but contradictory experiences were given. The reliability of lightning arresters was one of the things that came up, and Mr. Leslie said he had less trouble from lightning since abolishing them than while they were in use.

The World's Fair matter then came up for discussion, and there was a colloquy between Prof. Gray and Judge Armstrong with respect to the position of the association in the congress. The situation was fully explained and a committee was appointed, consisting of Messrs. Armstrong, Cushing and Candee, to report on the matter at the next session. Mr. Erastus Wiman was then introduced and was received with great pleasure. He prefaced his paper on the financial aspect of electric lighting by a few happy remarks concerning the Montreal Convention, in which he also took part, and then spoke of the great service of the electrical industries—especially electric lighting—in the development of modern civilization and the promotion of the commercial prosperity of the nation. He particularly discussed the matter with reference to the financial difficulties that had been met and ascribed them largely to the attempt to enter into disastrous competition with gas and other electrical lighting interests. The question of profit, he stated, yet remains to be decided in many localities. On the whole he held that the financial success of electric lighting has not been what it ought to be, although in some stations most excellent results had been attained. He closed with the suggestion that by combining the furnishing of power with the production of light a paying load could be kept up at the station during the 24 hours, and dividends materially increased. An appropriate vote of thanks to Mr. Wiman was passed at the conclusion of the paper, and the convention then adjourned to meet on Thursday morning.

Mr. Allen R. Foote opened the session of Thursday morning with a paper on the relations of electrical companies to the municipality, taking the view that liberal and perpetual franchises should be given. A brief discussion followed in which Judge Armstrong and Mr. Scott took the principal part.

Next in order was a brief but thoroughly practical paper by Mr. Hammond on how to fire a steam boiler, which was received with great enthusiasm. It dealt with the every-

day features of station operation, and both in the paper and the ensuing discussion attention was given to the great value of intelligent and well trained firemen, and to the saving of coal that could be effected if they attended properly to their duty.

The committee appointed to report on the relation of the National Electric Light Association to the World's Fair Electrical Congress then reported, and the most that could be said was that all due efforts would be made to interest the members as individuals in the proposed congress; further than this the association did not care to go, inasmuch as it could not take part as an organization.

Mr. E. F. Peck then read a useful paper on overhead construction, giving an idea of some of the precautions that should be observed in running overhead lines and some of the methods that might well be followed in installing and operating a large system upon the overhead plan. In the discussion Prof. Thomson and Mr. John A. Seely took part. The former called particular attention to the necessity of well trained linemen and to the bad results that have been due in the past to hasty construction carried out by men unfamiliar with the handling of heavy wires. Mr. Seely referred es pecially to the undesirable practice of using very large poles, stating that the experience of the telephone companies had shown that this practice was objectionable. Mr. Wightman and Mr. Van Trump also took part in this discussion. Then came a sharp debate between Mr. M. D. Law and Mr. Lockwood as to the methods of testing arc light circuits. Mr. Law advocated testing for open circuits with a rather weak dynamo current on the line, a practice which Mr. Law denounced as dangerous.

Mr. E. A. Leslie then read an excellent paper on underground service as instanced by that to be found in New York City. His view of the case was that while the conduit is practical and is indeed used on a large scale, and is less liable to interruption than overhead service, it is still enormously costly and inconvenient. After a brief discussion Mr. Craven read a valuable paper on the underground methods employed in running the feeders of the Buffalo Railway Company, and then the discussion of both the underground papers was taken up. Judge Armstrong took the sound position that the principal objection to overhead work was on æsthetic grounds, which, while not unreasonable in its way, should not be allowed to interfere too much with the development of a great industry. After a brief discussion the meeting adjourned, and the afternoon session was given over to executive work. A vote of thanks was tendered to Mr. C. O. Baker, Jr., for his services in securing transportation; to the citizens of Buffalo for their hearty welcome, and to the telephone companies for their kindness in extending the courtesies of the lines to the delegates.

The election of officers was then held, and resulted in the choice of Mr. Jas. I. Ayer, of St. Louis, as president, with Judge E. A. Armstrong, as first vice-president and Mr. C. H. Wilmerding as second vice-president. Messrs. H. H. Fairbanks, Robb Mackie and C. L. Abel were appointed upon the executive committee. This closed the formal meetings of what was universally esteemed a very successful convention. It was devoted strictly to business, and the central station contingent were well pleased with the character of the papers and the practical turn that the convention had taken. No summer meeting will be held this year. The next convention will take place a year hence at St. Louis.

In the evening occurred the banquet to the delegates of the association, which was so interesting and agreeable an occasion as to be well worth the special notice we have given it elsewhere in this issue.

Moonlight Tables for March, 1892.

Herewith we give Mr. H. W. Frund's table of lighting hours for the month of March, under his modified form of moon schedule:

TABLE NO. 1.
Standard Moonlight, Philadelphia System.

Date.	Light.	Date.	Exting.
1	6:25 P. M.	2	5:30 A. M.
2	6:25	3	5:30
3	10:40	4	5:30
4	11:55	5	5:30
5			
6	1:05 A. M.	6	5:25
7	2:05	7	5:20
8	3:00	8	5:20
9	3:45	9	5:20
10	4:20	10	5:15
11	No light.	11	No light.
12	No light.	12	No light.
13	No light.	13	No light.
14	No light.	14	No light.
15	6:40 P. M.	15	9:15 P. M.
16	6:40	16	10:15
17	6:40	17	11:15
18	6:40	19	12:20 A. M.
19	6:40	20	1:20
20	6:45	21	2:25
21	6:45	22	3:20
22	6:45	23	4:15
23	6:45	24	4:50
24	6:45	25	4:50
25	3:50	26	4:50
26	6:50	27	4:50
27	6:50	28	4:50
28	6:50	29	4:45
29	6:50	30	4:45
30	6:55	31	4:45
31	6:55	1	4:45

Total hours lighting, 180.25.

TABLE NO. 2.
Frund's New Moonlight System.

Date.	Light.	Date.	Exting.
1	6:25 P. M.	2	5:30 A. M.
2	6:25	3	5:30
3	6:25	4	5:30
4	6:25	5	5:30
5	6:30 P. M.	5	12:00 M.
6	1:05 A. M.	6	5:25 A. M.
6	6:30 P. M.	6	12:00 M.
7	2:05 A. M.	7	5:20 A. M.
7	6:30 P. M.	7	12:00 M.
8	3:00 A. M.	8	5:20 A. M.
8	6:30 P. M.	8	12:00 M.
9	3:45 A. M.	9	5:20 A. M.
9	6:30 P. M.	9	12:00 M.
10	6:35	10	12:00
11	6:35	11	12:00
12	6:35	12	12:00
13	6:35	13	12:00
14	6:35	14	12:00
15	6:40	15	12:00
16	6:40	16	12:00
17	6:40	17	12:00
18	6:40	19	12:20 A. M.
19	6:40	20	1:20
20	6:45	21	2:25
21	6 45	22	3:20
22	6:45	23	4:15
23	6:45	24	4:50
24	6:45	25	4:50
25	6:50	26	4:50
26	6:50	27	4:50
27	6:50	28	4:50
28	6:50	29	4:45
29	6:50	30	4:45
30	6:50	31	4:45
31	6:55	1	4:40

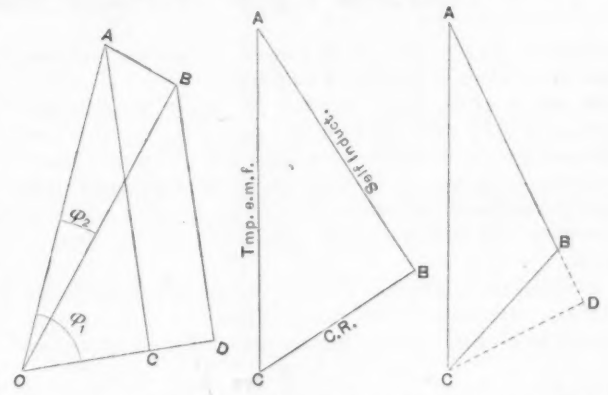
Total hours lighting, 254.50.

Precautions to be Observed in Applying Corrections to Wattmeter Readings.

BY ERNST DANIELSON.

When using a wattmeter for measuring the energy which is expended in a circuit in which an alternating current flows, we have, as is well known, to apply a correcting factor which in some cases can have a value considerably differing from 1. With the assumption that we have to deal with E. M. Fs. and currents which follow the simple periodic law of a sine curve, the correcting factor has been proved to be $\frac{1 + \lambda_2^2}{1 + \lambda_1 \lambda_2}$ in which formula λ_2 is equal to $\frac{2 . \pi . n . L_2}{\gamma_2}$ where L_2 = the coefficient of self-induction of the potential circuit of the wattmeter, γ_2 the resistance of the same circuit and n equals the number of complete periods per second, and $\lambda_1 = \frac{2 \pi . n . L_1}{\gamma_1}$; L being the coefficient of self-induction of the circuit in which the watts consumed are to be measured, and γ_1 the resistance of the same circuit. This is the explanation generally given. The aim of this investigation is to show that under certain circumstances we may introduce an error by using this formula without considering other factors.

At first let us show in the simplest possible way how the formula is obtained. Suppose (see figure) $O A$ to be the direction and magnitude of impressed E. M. F., $A O C = \varphi_1$ the angle by which current in the circuit—the watts of which are to be measured—lags behind the impressed E. M. F., and $A O B = \varphi_2$, the angle which current in potential circuits lags behind the E. M. F. Now if $A C$ is at right angles to $O C$, then, according to the common rule that $\overline{\text{Impressed E. M. F.}}^2 = \overline{\text{Self-induction}}^2 + C^2 R^2$, the current in the main circuit would be $\frac{O C}{\gamma_1}$. For the same reason if $A B O$ equals a right angle $\frac{O B}{\gamma_2}$ would be the current in the potential circuit. As the readings of an instrument built on the dynamometer principle are proportional to the product of the currents in the stationary and



FIGS. 1, 2 AND 3.—DIAGRAMS ILLUSTRATING THE PRECAUTIONS TO BE OBSERVED IN APPLYING CORRECTIONS TO WATTMETER READINGS.

the movable coil times the cosine of their difference in phase, then the watts read in our case will be proportional to the main current times $O D$; $O D$ being $= O B . \cos (\varphi_1 - \varphi_2)$. But the energy which we ought to have read is proportional to the main current times $O A . \cos \varphi_1$. (= current $\times$ $O C$). The correcting factor, accordingly, is $\frac{O C}{O D}$. The value of this fraction is easily obtained.

$$O D = \frac{O C}{\cos \varphi_1} . \cos \varphi_2 . \cos (\varphi_1 - \varphi_2), \text{ and}$$

$$\frac{O C}{O D} = \frac{\cos \varphi_1}{\cos \varphi_2 . \cos (\varphi_1 - \varphi_2)} =$$

$$\frac{\cos \varphi_1}{\cos^2 \varphi_2 . \cos \varphi_1 + \cos \varphi_2 . \sin \varphi_1 . \sin \varphi_2}$$

By dividing numerator and denominator with $\cos \varphi_1 . \cos^2 \varphi_2$ and substituting tangents for sines and cosines we get the correcting factor $= \frac{1 + \text{tg}^2 \varphi_2}{1 + \text{tg } \varphi_1 . \text{ tg } \varphi_2}$. Now the tangent of the angle which a current lags behind the E. M. F. is in the text books proved to be $\frac{2 . \pi . n L}{r}$; (L = coefficient of self-induction; r = resistance; n = complete cycles per second). Supposing this to hold good, we find that the formula $\frac{1 + \text{tg}^2 \varphi_2}{1 + \text{tg } \varphi_1 . \text{ tg } \varphi_2}$ is identical with $\frac{1 + \lambda_2^2}{1 + \lambda_1 \lambda_2}$.

The question arises, however, whether it is always true that $\frac{2 . \pi . n . L_1}{\gamma_1} = \text{tg } \varphi_1$. In practice we have in general to deal with circuits containing iron. If this iron is not laminated, Foucault currents will be set up in it, and whether laminated or not it will always be the seat of hysteresis. The effect of hysteresis and Foucault currents is to cause the magnetism to lag in phase behind the magnetizing current. The result then will be that the phase of self-induction will no longer be 90 behind the current, but it is retarded as much more as corresponds to the lag of magnetism behind the current. In this case, therefore, the diagram of impressed E. M. F., self-induction and $C R$ will not be a right-angled triangle, as in Fig. 2, but the shape is changed to something like Fig. 3, in which $A B$, $A C$ and $B C$ correspond to $A B$, $A C$ and $B C$ in Fig. 2, and $C D$, which is at right angles to $A B$, shows the direction of magnetism. If in this case volts, ampères and ohms are measured, and L afterward figured from the formula $C = \frac{F}{\sqrt{R^2 + 4\pi^2 n^2 L_2}}$ which is based on the assumption that the diagram is a right-angled triangle, it is evident that the value of L obtained will be greater than the real coefficient of self-induction, and that the angle between E. M. F. and current figured from these data would be larger than the real angle.

Now, a very small difference in this angle may sometimes cause a large error in the correcting factor of the wattmeter, which may result in having the "corrected watts" more erroneous than the "read watts."

As this is a fact which seems to have been neglected when applying the formula above mentioned, let us by a couple of examples show what this error may amount to.

In Kittler's valuable book "Handbuch der Elektrotechnik," he figures the correction for a wattmeter when using it for measuring the core loss of a transformer. The coefficient of self-induction of the primary of transformer with secondary open, is given to be $L_1 = 4$ henries, resistance = 1 ohm, and for the potential circuit of wattmeter $L_1 = 0.0015$ henry with a resistance of 20,000 ohms. From these data, and having 85 alternations = 42.5 cycles per second he gets $\lambda_1 = \frac{2 . \pi . 42.5 . 4}{1} = 1068$ and $\lambda_2 = \frac{2 . \pi . 42.5 . 0.0015}{20000} = 0.00002$. These values give a correcting factor = 0.98, with which the readings of the wattmeter should be multiplied in order to obtain the real watts consumed. In this figuring $\lambda_1 = 1068$ should be the tangent of the angle of lag between E. M. F. and current. Now arc tang $1068 = 89^\circ\ 57'$ which, accordingly, should be the angle between E. M. F. and current in primary when secondary is open. Kittler has himself, however, shown that in this transformer that angle is $73^\circ\ 57'$. (This is for $n = 50.5$ cycles instead of 42.5, but this difference causes no material change in the angle.) The real value of λ_1 therefore is $tg\ 73^\circ\ 57' = 3{,}476$ and the correcting factor is $\frac{1}{1.00007} = 0.99993$ instead of 0.98. We find that in this case the value read directly was better than the "corrected."

Fortunately, this wattmeter was so sensitive as to allow its being used in the primary circuit, and therefore of using a very great resistance in the potential circuit. With a less sensitive instrument the error may be increased in an astonishing degree. Another example will show this.

The core loss of a transformer was to be measured and the measuring had to be made with the wattmeter connected to the secondary circuit in order to get a good deflection. Voltage was 50 as read with a Cardew. With primary circuit open the current in secondary was 20 ampères. (The transformer was one with open magnetic circuit, therefore the leakage current was considerable). Number of cycles per second was 125 and resistance of secondary = 0.0085 ohm. Accordingly, $20 = \frac{50}{\sqrt{0.0085^2 + (2 . \pi . n L)^2}}$ which gives $L = 0.00318$ henry.

The coefficient of self-induction of the potential circuit was experimentally found to be 0.00155 henry, and total resistance in same circuit was 200 ohms. From these data we figure

$$\lambda_1 = \frac{2 . \pi . 125 . 0.00318}{0.0085} = 294$$

$$\text{and } \lambda_2 = \frac{2 . \pi . 125 . 0.00155}{200} = 0.00609$$

$$\text{which gives } \frac{1 + \lambda_2^2}{1 + \lambda_1 \lambda_2} = \frac{1 + 0.00609^2}{1 + 0.00609 . 294} = \frac{1}{2.78}$$

According to this the reading of the wattmeter, which was 90 watts, should be multiplied by $\frac{1}{2.78}$ to get the real loss in the transformer. This loss then should be $\frac{90}{2.78} = 32.2$ watts. It might be immediately suspected that this result is not correct. Let us first show that it really is incorrect and afterward how we can find the correct value.

Our figuring was based on a value of λ_1, $= 294$. Supposing this to be true, then it means that the angle between main current and E. M. F. is arc tang $294 = 89^\circ\ 48'$. As the energy in watts which is used up in a circuit equals the product of the current, voltage and cosine of the angle of lag—current and voltage being measured by instruments reading the square root of the mean square—then $20.50 \cos 89^\circ\ 48'$ ought to give 32.2 watts, but instead it gives 3.4 watts. As these values do not agree, either the 32.2 watts, or the angle $98^\circ\ 48'$, or both, must be erroneous. Now the watts are figured on the basis of the angle, therefore both must be incorrect.

In order to get the real value of watts it is necessary to have simultaneous readings of ampères and volts, as well as the watt reading. If these data are known the following method presents itself for finding the real watts and at the same time the true angle between current and E. M. F.

Ampères as read by a dynamometer = A.
Volts as read by a Cardew = V.
Watts as read by the wattmeter = W.
Real watts = w.
Angle between current and E. M. F. as before = φ_1.

Concerning these quantities, following relations must hold good. $w = A \,.\, V \,.\, \cos \varphi_1$.

$$w = W \frac{1 + \lambda_2^2}{1 \lambda_1 \lambda_2}$$

The combination of these two equations gives the valuest of w and φ_1. For our present problem we get

$$w = 20.50 \cos \varphi_1 \qquad (1)$$

$$w = 90 \frac{1 + 0.00609^2}{1 + 0.00609 \operatorname{tg} \varphi_1} \qquad (2)$$

In solving this system of equations, eliminate w and substitute tg φ_2 for 0.00609. This gives

$$\cos (\varphi_1 - \varphi_2) = 0.09$$

$$\therefore \varphi_1 - \varphi_2 = 84^\circ\ 50'$$

$$\varphi_1 = 84^\circ\ 50' + \text{arc tg}\, 0.00609 = 85^\circ\ 11'.$$

Substituting this angle for φ_1 in equation (1), we ge $w = 20.50 \cos 85^\circ\ 11' = 83.9$ watts, which is the real value of the loss in the transformer, and considerably differing from 32.2, which was figured without taking into consideration the retarding influence of hysteresis and Foucault currents in the iron.

Summarizing these results we arrive at the following conclusions: When using the formula $\frac{1 + \lambda_2^2}{1 + \lambda_1 \lambda_2}$ for correcting a wattmeter reading taken on a circuit which encloses iron, or any conductor which on account of qualities or shape can be the seat of hysteresis or foucault currents, it is not safe to write $\lambda_1 = \frac{2 . \pi . n . L_1}{\gamma_1}$ and figure L_1 from corresponding values of volts, ampères, ohms and frequency when an alternating current passes. In such a case the correct value of watts is necessarily larger than the wattmeter reading multiplied by the correcting factor obtained as described. In order to find the real amount of energy expended, readings of ampères and volts should be taken simultaneously with watt readings, and the true angle of lag and true watts ascertained, as shown above.

Lubricating Oils.

Mr. Lane, of Cleveland, O., in an address at the Buffalo convention of the National Electric Light Association, on the subject of lubricating oils, said that most people were under the impression that it was necessary to use lubricating oils of high viscosity and low gravity in order to get good lubrication on heavy or high speed machinery. He said that after extended experiments it had been found that a light oil, light in gravity and low in viscosity, was the oil that would give the best satisfaction in the lubrication of both high speed and heavy machinery. In the case of machinery running at very high speed, an increase of oil will increase the temperature; and unless you use oil enough to absorb the heat, so that the oil will run away, taking the heat with it, you cannot reduce the heat by a large amount of oil; that is, if you use more than is really necessary for lubrication, but fall below the point necessary to carry the heat off with the oil. The oil recommended by Mr. Lane was an oil about 32 gravity and 140 viscosity. He instanced the Calumet & Hecla mines, where lard oil was used up to two years ago, but they now use a mineral oil. Objection was sometimes raised to cylinder oils because they produced a gummy substance; but he claimed that this gummy substance was usually due to a scale-making material in the steam, and which is deposited on the walls of the cylinder; as a rule, therefore, any oil that will produce a gummy substance is a good oil, as it cleans the cylinder of this injurious substance.

Power Transmission.

BY WM. M. SCHLESINGER.

In all the articles so far written on power transmission, the subject has been looked upon entirely from the standpoint of the consumer of the power, and all the formulæ given so far are intended to show under what conditions he will be able to derive this power at a minimum cost. These formulæ give the well known laws of minimum operating expenses, which, for water power, mean that the first cost of installation must be a minimum. Now it is evident that outside of the large number of power transmissions being put in by parties who at the same time are the consumers of the power, there is a large field for power transmission plants owned by individuals or companies who rent the power to the consumer. An example of such an enterprise can be found in the proposed plant at Niagara Falls.

Looking at the problem from the standpoint of the owner of the power (either water or steam), it is not so much a question of making the cost per horse power delivered by the motor a minimum, as it is one of making the net profits derived from each horse power available at the generating plant a maximum. It is a well known fact that the condition of minimum cost of operating does not necessarily give a very efficient plant. If the power can be sold at a certain value, c, per horse power delivered by the motor, it can readily be conceived that, although the profits per horse power delivered will be a maximum, under the conditions of minimum operating expenses (that is, c = operating expenses per horse power delivered), yet by slightly increasing the cost of operating expenses the efficiency of the plant may be increased so that the product of available horse power into profit per horse power delivered may become larger. When this product becomes a maximum we will have the plant giving the best returns for the money invested, or, in other words, we will have the conditions giving the most profitable plant.

In the following I shall endeavor to give the laws covering this problem, and also to show how they can be applied for the purpose of answering the various questions of interest to owners of such properties.

The owner of a power plant does not primarily care for the number of horse power actually delivered. His object is to derive most profit out of each horse power available at the source of power. Starting now with a horse power at the power station, and using generators having an efficiency of d per cent., we will then have at the brushes of the generator $a\,d$ h. p., giving the E. M. F. at the generator as E volts; and supposing that the loss in the line will be v volts, we will then have $ad\,\frac{(E-v)}{E}$ h. p. available at the motor brushes; and if the efficiency of the motor is m per cent., we will have $a\,d\,\frac{(E-v)}{E}\,m$ h. p. available at the motor pulley. If now, furthermore, we designate with

A, the cost of the water wheels or steam engine per h. p.

D, the cost of generator per electrical h. p., delivered at the brushes.

M, the cost of the motor per h. p., delivered at the motor pulley.

l, the distance in feet between generator and motor.

b, the cost of wire insulated per mil foot.

P, the cost of pole line per foot, including labor of stringing wire, etc.

C. general expenses.

We will have the cost of our plant.

$$a\,A + D\,a\,d + \frac{31{,}332\ l^2\ a\,d\,b}{E\,v} + a\,M\,d\,m\,\frac{E-v}{E} + P\,l + C$$

and as available h. p. $= a\,d\,m\,\frac{E-v}{E}$

The operating expenses of a power plant can be divided into two parts, of which the first is a certain fixed sum (N) independent of the cost of the plant, and including attendance, fuel (if steam is used), oil, waste, etc., and the other part is a certain percentage (y) of the cost of the power plant, and covers depreciation, interest, insurance, taxes and allowance to cover accidents to the machinery. We can, therefore, place the operating expenses at the plant at

$$N + y\,(\text{cost of plant}) \text{ dollars.}$$

As we can get c dollars for every horse power delivered at the motor pulley, our profits will be

(available horse power) $c - N - y$ (cost of plant) or

$$a\,d\,m\,c\,\frac{E-v}{E} - N - y\,A\,a - y\,D\,a\,d - y\,\frac{31{,}332\ l^2\ a\,d\,b}{E\,v}$$

$$- y\,a\,M\,d\,m\,\frac{E-v}{E} - y\,(P\,l + C)$$

or the profits per horse power available at the generating station will be

$$d\,m\,c\,\frac{E-v}{E} - \frac{N}{a} - y\,A - y\,D\,d - y\,\frac{31{,}332\ l^2\ d\,b}{E\,v}$$

$$- y\,M\,d\,m\,\frac{E-v}{E} - y\,\frac{P\,l + E}{a}$$

If we place the first differential of this expression = 0, we will get the condition for which the profits will be a maximum; or

$$-\frac{d\,m\,c}{E} + y\,\frac{31{,}332\ l^2\ d\,b}{E\,v^2} + y\,\frac{M\,d\,m}{E} = 0$$

or

$$(1) \qquad v = l\sqrt{\frac{31{,}332\ d\,b\,y}{m(c - M\,y)}}$$

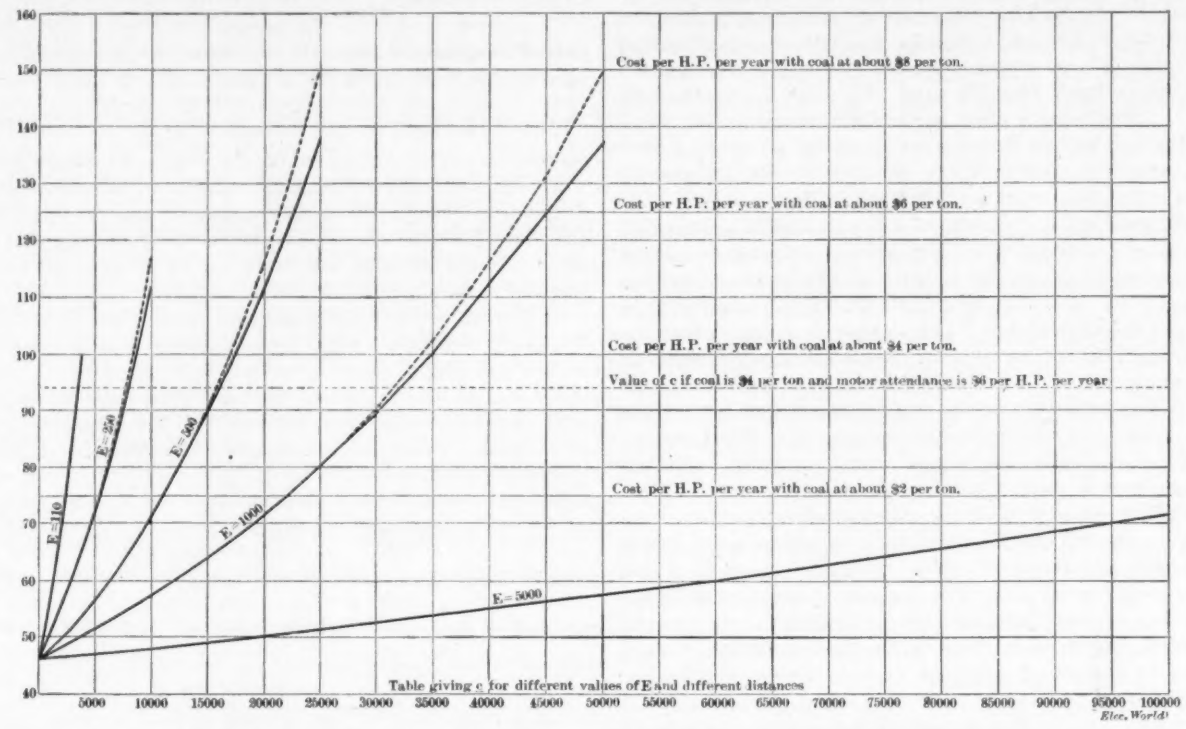

Cost per H.P. per year with coal at about $8 per ton.
Cost per H.P. per year with coal at about $6 per ton.
Cost per H.P. per year with coal at about $4 per ton.
Value of c if coal is $4 per ton and motor attendance is $6 per H.P. per year
Cost per H.P. per year with coal at about $2 per ton.
E=250
E=500
E=1000
E=5000
E=110
Table giving c for different values of E and different distances
Elec. World

DIAGRAM 1.—COST OF POWER TRANSMITTED AT VARIOUS VOLTAGES.

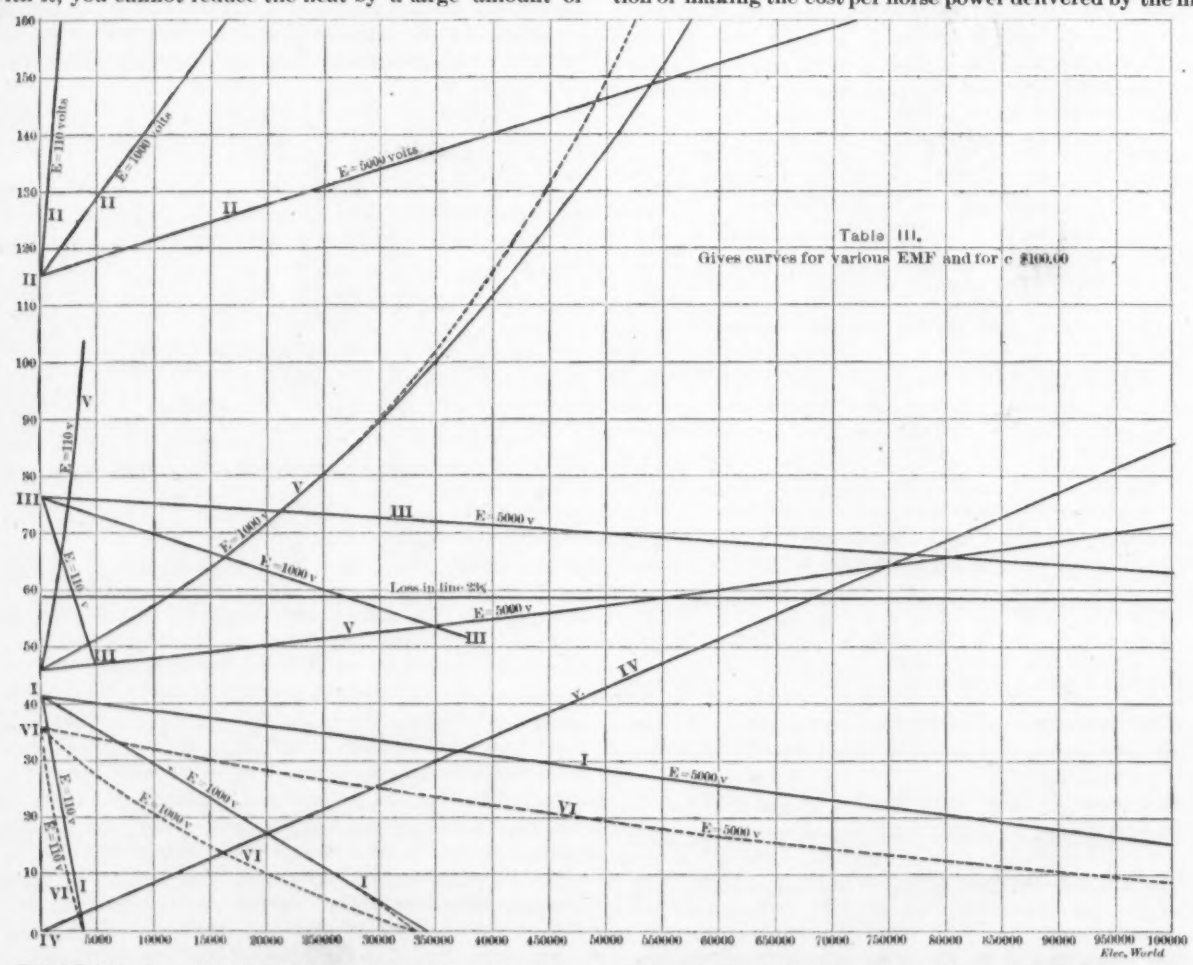


DIAGRAM 3.—CURVES FOR VARIOUS VOLTAGES AND FOR POWER COSTING $100 PER H. P.

By introducing this value into our expressions giving the cost of plant and profit, we get, as cost of most profitable plant, per horse power, at generating station

$$(2)\ A + d\,D + \frac{l}{E}\,d\sqrt{\frac{31{,}332\,b\,m\,(c - My)}{y}} + M\,d\,m - M\,d\,\frac{l}{E}\sqrt{\frac{31{,}332\,b\,m\,y}{c - My}} + \frac{P\,l + C}{a}$$

and the profit derived from such a plant per horse power at the generating station will be

$$(3)\ d\,m\,c - \frac{N}{a} - y\,A - y\,D\,d - \frac{l}{E}d\sqrt{\Big(31{,}332\ b\,m\,y\,(c - My)\Big)} - y\,M\,d\,m - (d\,c - y\,M\,d)\,\frac{l}{E}\sqrt{\frac{31{,}332\,b\,m\,y}{c - My}} - y\,\frac{P\,l + C}{a}$$

We furthermore get, as expression of available horse power at the pulley of the motor

$$(4)\qquad d\,m\left|1 - \frac{l}{E}\sqrt{\frac{31{,}332\,b\,y}{m\,(c - My)}}\right.$$

A comparison between the formula, for these conditions, and those giving the conditions of minimum operating expenses, is very interesting. In the expression for v, for example, we notice that the cost of primary power and of the generator is not included, these now being constant values. On the other hand v is dependent on M, or the cost per horse power of the motor. This is evidently very much more desirable. It has always been assumed that it is possible to fix upon a constant value per horse power for the generator and engine (or water-wheel), and that by multiplying these constants with the number of horse power found to be required at the generating station it would be possible to find the actual price of the generating plant. As both generators and engines are used in large units, this assumption is incorrect. For example, the calculation for minimum operating expenses might call for a 130-kilowatt generator, and the nearest available size might be found to be a 150-kilowatt generator.

When water power is used it is still more difficult to decide on the value per horse power for the power plant. The cost of a water power is made up of a value not directly dependent on the amount of power, and on a value directly dependent on the amount of power to be delivered. The first of these values may, however, be greatly altered if the amount of power required should exceed a certain fixed limit. If, for example, 1,000 h. p. only should be required, the necessary ducts may be quite short. To allow for an additional 100 h. p., however, it may be found necessary to triple or quadruple the length of these ducts. Instead of an increase of 10 per cent. only in the price, we would have a by far larger increase. Motors, on the other hand, are as a rule used in small units, so that it is very much easier to arrive at a fixed average value per horse power for these. If in the formula found above we insert the following values:

a = 1,000 h. p.; A = $40 per horse power; B = $40; M = $50; b = $90 per 100,000,000 mil feet of insulated wire; P = $10 per foot; C = $1,300 (per 1,000 h. p.); d (efficiency of generator) = 90 per cent.; M (efficiency of motor) = 85 per cent., and assuming that the power is required during 10 hours per day only, and that water is the primary source of power, we get as values of the fixed part of the operating expenses, N = 12.1 per horse power, not including wages of motor tenders. (See Hale's paper on power transmission.) We will also place v at 20 per cent. We then get:

$$(1)\qquad v = l\frac{.0815}{\sqrt{c - 10}}$$

$$(2)\ \text{Cost} = 115.55 + \frac{l}{E}\left(.3114\sqrt{(c - 10)} - \frac{3.114}{\sqrt{c - 10}}\right) + .0001\,l$$

$$(3)\ \text{Profit} = 41.29 + \frac{l}{E}.1246\sqrt{c - 10} - .00002\,l$$

$$(4)\ \text{Av. h. p} = .765\left|1 - \frac{l}{E}\frac{.0815}{\sqrt{c - 10}}\right.$$

by combining two and three we will get as per cent profit

$$(5)\ \text{P. ct. profit} = \frac{\text{profit}}{\text{cost}} = \frac{41.29 - \frac{l}{E}.1246\sqrt{c - 10} - .00002\,l}{115.55 + \frac{l}{E}\left(.3114\sqrt{c - 10} - \frac{3.114}{\sqrt{c - 10}}\right) + .0001\,l}$$

If in equation three we place the profit equal to 0, we find

$$(6)\ c = .01324\,\frac{l^2}{E^2} + .163\,\frac{l}{E}\sqrt{\left(.00662\,\frac{l^2}{E^2} + 36 + .00000262\,l\right)} + 46 + .00000262\,l.$$

This last formula and the curves deduced from it are the most important of the entire set. In Table I. the different values for the horse power per year, with coal at various prices, are given by the horizontal lines, and the different values for c, taken from the formula, have been plotted for various E. M. F. at the generator. This table enables us to answer the most important question of practicability of proposed power transmission. Should a mine owner, for example, desire to use a water power l feet from his mine, and if the horse power produced by steam at the mine cost him c dollars per year, and if, furthermore, he is limited to the use of an E. M. F. of E volts, then the curve giving c for E volts will at once enable him to determine whether the scheme is practicable or impracticable, for if the ordinate erected at l cuts the curve beyond the point of its intersection with the horizontal line, giving the value of c, it will cost him more for his power if he procure it from the water power than if he continues to use steam. If the ordinate erected on l cuts the curve at its intersection with the horizontal line c, the cost of the power derived from the transmission will just equal the cost of the power derived from steam; and if the ordinate erected on l intersects the curve between the point of its intersection with the horizontal line c and the axis, it will be cheaper for the mine owner to derive his power from the waterfall than by means of steam generated at his mine.

In addition to this, the following problems can be answered by means of these curves:

Given the E. M. F. of the generator and the distance to which the power is to be transmitted, the curves will show

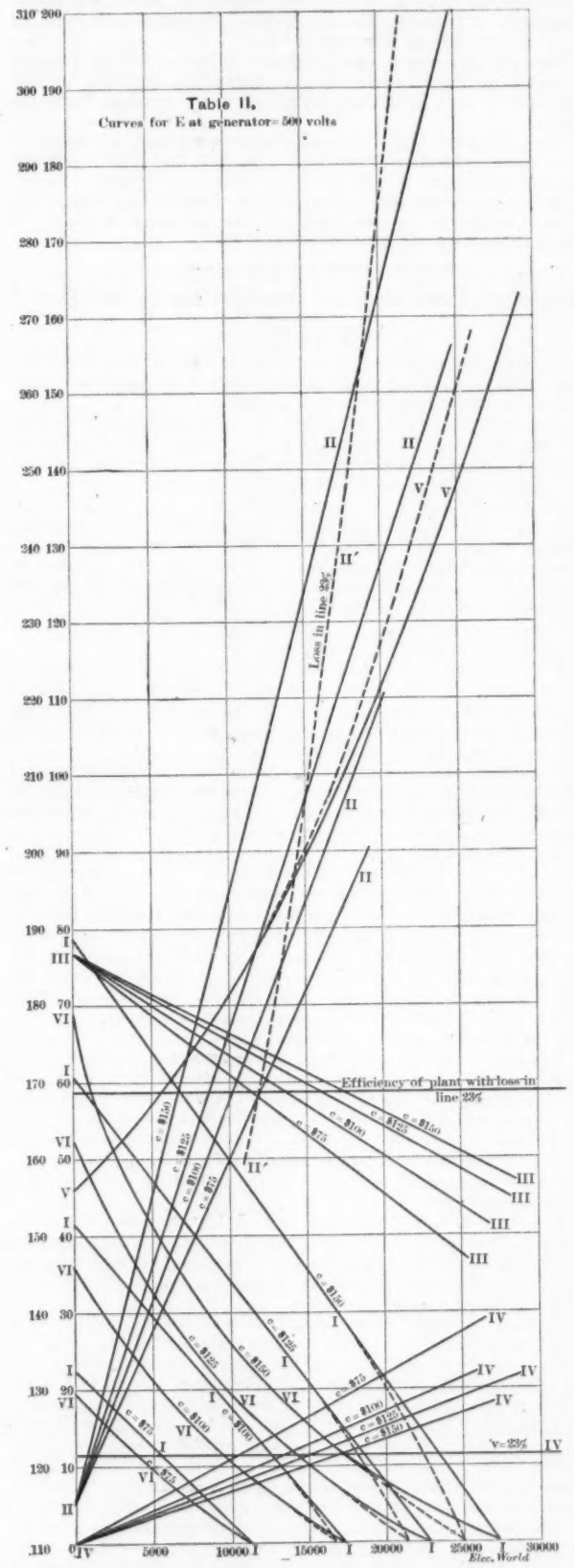


DIAGRAM 2.—CURVES OF COST OF POWER WHEN E. M. F. AT THE GENERATOR IS 500 VOLTS.

the minimum charges that ought to be made per horse power delivered, if the plant is to be operated without loss.

Given the distance to which the power is to be transmitted, and the sum which can be obtained per horse power delivered, the curves will show the minimum E. M. F. that can be used.

And given the E. M. F. at the generator and the price which can be obtained per horse power delivered, the curves will show the greatest distance to which the power can be transmitted without operating at a loss.

Examining Table I., we furthermore find that when restricted to the use of a certain E. M. F., no matter what the value of c may be, it will not be practicable to transmit the power beyond a certain distance. If we adopt the rule laid down by Mr. Hale in his paper, that the largest practicable loss in the line should be limited to 23 per cent., these curves will be modified, as shown by the dotted curves. We now find the limit to which power can be transmitted with an E. M. F. equal to 110 volts is about 6,000 feet, and if the loss in the line is limited to 23 per cent., this distance is reduced to 4,000 feet. If 500 volts can be used, the greatest distances are 35,000 feet and 30,000 feet, respectively; and with 1,000 volts the distances are 60,000 feet and 55,000 feet, respectively.

In Table II. the curves have been plotted from the various formulæ for different values of c and for an E. M. F. of 500 volts at the generator. Curves 1 give the profit derived per horse power per year for each horse power available at the generator and for different values of c If, for example, c is equal to $150 per year, we find that the maximum profit we could make per horse power average at generator would be $78.25; but in this case the motor would have to stand right at the side of the generator. With c at the same value, the receipts per horse power delivered will just balance the operating expenses, at a distance of 27,300 feet, or, if we limit the loss in the line to 23 per cent., at a distance of 25,000 feet. Curves 2 give the cost of the most profitable plant for horse power average at generator. With c at $75, for example, we find that if the power is to be transmitted a distance of 10,000 feet, our entire plant would cost us about $160 per horse power average at generator. Curve 2′ gives the cost per horse power of the power transmission plants in which, independent of the distance to which the power is to be transmitted, the loss in the line is placed at 23 per cent. We now find that with c equal to $125, l equal to 20,000 feet, the cost of the plant per horse power average at generator would be $237 if no limitations as to loss in line are made, and $284.50 if the loss in line is limited to 23 per cent. In the former case the profit derived from the plant would be $7.50 per horse power average at generator and in the latter case it would be $4.75 per horse power average at generator. Curve 3 gives the total efficiency of the plant, or the number of horse power available at the motor pulley. Curve 4 gives us the drop in the line. Curve 5 is the same curve as given for 500 volts in Table I., and curve 6 gives us the profit derived from the plant in percentage of the sum invested.

An example may best show how the table can be used. Given a water power at a distance of 12,000 feet from a place at which the power is required, let the E. M. F. be limited to 500 volts, the loss in the line to 23 per cent. By following the ordinate marked 12,000 to its intersection with curve 5, we find that the transmission will be practicable if power can be sold at a price not lower than $79 per horse power delivered by motor. Now, let us suppose that we can get $100 for each horse power delivered, then curve 1 shows that our profits will be $12.75 per horse power average at generator. Curve 2 shows us that the entire plant will cost us $178.25 per horse power average at generator; curve 3 shows that there are 608 h. p. available at the motor pulley for each 1,000 h. p. available at generator; curve 4 shows that the drop in the line will be 102 volts, and curve 6 gives us as profit on the plant in percentage of the investment 7.1 per cent.

Table III. shows some of these curves for the different E. M. F.

In the above the cost of attendance for motor has been omitted, but this can be easily taken into account by deducting from the value for c the cost of attendance per horse power per year that may be found for each particular case. Should, for example, at a mine where 100 h. p. is used it be deemed necessary for a man who received, say, $1,200 per year, to devote half his time to the power plant, then the amount to be deducted from c will be $6.

Similar formulæ and tables can be prepared to determine the conditions if the plant is to work 24 hours per day, or if the source of primary power is steam instead of water, In a large number of cases it will also be found perfectly feasible, especially where small motors are being used, to install a larger motor capacity and to rent more power than the power plant would be capable of giving. These are the same conditions as found in most of our electric light stations. The only alteration in the formula this latter condition would make would be in multiplying m (the efficiency of the motor) by a certain value, giving the ratio of the motor power actually installed or rented to the power the plant is capable of delivering.

Fires and Injuries Caused by Electric Currents During the Year 1890.*

BY ALLEN R. FOOTE.

The following data were obtained from 425 cities in the United States:

Number of members on fire force, regular and volunteer	56,498
Total number of fires for which the force was called out	39,847
Total number of fires caused by electric currents	518
Total number of injuries received while on duty	1,719
Total number of injuries received while on duty at fires caused by electric currents	35
Total number of injuries caused by electric currents to men while on duty	31
Total number of fatal injuries received while on duty	60
Total number of fatal injuries caused by electric currents to men while on duty	1

[In the brief remarks following the reading of the above data it was shown that in the single case of a fatal injury caused by electric currents to an attendant while on duty, a man fell from a pole thirty-five feet high, and as there was no autopsy, it could not be learned what the exact cause of death had been.]

* Abstract of a report read at the Buffalo Convention of the National Electric Light Association, Feb. 23, 1892.

How to Fire a Boiler.*

BY R. HAMMOND.

It has been said "that the waste of fuel due to improper firing is often of more consequence than any other loss which is produced in the operation of a steam plant," but in a great many cases the waste of fuel cannot be entirely charged to improper firing, as there are other causes by which a waste of the evaporating power of the fuel is produced. The principal of these are the following:

The improper construction of the boiler in relation to grate surface, tube area, heating surface and combustion chambers. Unless these proportions are properly worked out, it matters little whether the firing be done by mechanical means or by the more intelligent fireman, waste of fuel must necessarily follow. A great many contrivances have been placed on the market, such as mechanical stokers and other means by which coal and air can be supplied to the furnaces of steam boilers for the purpose of obtaining good combustion without producing a waste of heat by allowing too much air to pass above the grates, or an insufficient supply below the grates. By this statement I do not mean that any particular method of firing will produce any more heat from a pound of coal than nature put into it. Just as good results can be obtained from hand firing as have been obtained by the best mechanical means.

It is often the case that firemen are paid insufficient wages for the work they are expected to do. We should be as particular to have good firemen in charge of our boilers as we are in having good engineers in charge of our engines. A good fireman should be just as capable of manipulating the furnaces of his boiler so that his steam recorder and his coal and water records will show just as good cards as the engineer can show in the manipulation of the steam he uses in his engine. If we paid the same attention to all the details of the construction and setting of our boilers and their economical use of fuel as we do to our engines our steam plants would be far more economical. Everything is "*shined up*" about the engine; engineers go into all the details of its construction and management and the greatest care is taken in the figuring out of its proportions so that it will have the very highest possible initial steam pressure and temperature and the very lowest possible terminal temperature and pressure; all endeavoring to get the greatest horse power from the pound of coal, thus securing the greatest economy—these very same highly educated individuals, who designed these engines, forget that all the power comes from the pound of coal and pay little attention to how that power is transmitted from the coal pile to the engine. It is just as essential to good economy that the boilers should have the very highest initial or furnace temperature, and the highest possible steam pressure, and the lowest possible chimney temperature, as it is for the engine to be economical under similar conditions of high initial pressure and temperature and low terminal temperature.

Experiment has proved that bituminous coal requires 150 cubic feet of air per pound of coal for good combustion. An excess of air results in a waste of heat which it carries into the flues and chimney, and often a greater loss in an insufficient supply to produce good combustion.

In my experience, for steam plant boilers carrying 80 to 160 pounds of steam, I find that at least 20 pounds of bituminous coal should be burned per square foot of grate per hour, and the air spaces of the grates should not be less than 50 per cent. of the grate area and the draught pressure not less than 2½ inches of water. If the grate surface is so large that only 10 pounds of coal are consumed, it would be more economical to reduce the grate surface and burn not less than 20 pounds with good draft, thus securing a good combustion. The same weight of coal burned on a large grate would not be as economical on account of the low temperatures. The temperature of the furnaces should not be less than 3,500 degrees, and the ratio of the draft area through the tubes or flues should not be less than one-sixth nor more than one-fourth of the grate surface, and the proportion of heat surface to grate surface should be at least as 35 to 1.

Under the conditions just stated boilers should be fired very economically, whether done by mechanical means or by hand. I have noticed in firing marine boilers on the great lakes that the firemen spread their coal evenly over the entire grate at each firing, and they produce steam very economically, while firemen on coastwise steamers will pile up the coal just inside the furnace door, and as it becomes coked will rake it back over the incandescent fire and grate with equally as good but no better results in the way of economy than obtained by the lake firemen. Both of these ways of firing are equally good, but in all cases the grate bars should be entirely covered, and the amount of air required above the grate should be admitted from above instead of below the grate.

Different grades of bituminous coal require different methods of firing and by a little experiment the experienced fireman soon finds out and adopts the best method of firing, and in all cases he should keep his flues and tubes clear of ashes and soot, as well as his fires and grate bars. In firing anthracite coal, the coal must be spread evenly over the grate in all cases, and like bituminous coal must be burned at a high temperature with good draft.

The steam users should see to it that all parts of their boilers and settings are of equally as good proportions for strength and economy as their engines, employ good intelligent firemen as well as engineers, and see that both produce good indicator cards. By a little attention in this direction steam users will themselves soon become experienced firemen and engineers and can readily tell whether the firemen and engineers are doing their duty.

The paper was praised and discussed at some length by a number of the members, the consensus of opinion being that it is of the utmost importance to pay more attention to firing than is usually given it, or, as Mr. Armstrong very pertinently put it: "We are more apt to soar aloft into intricate problems and shout for the beautiful results of fine workings in electric problems, and pass by these supposed unimportant factors." Or Mr. Edison, when he said: "Anywhere from 1 to 30 per cent. or more of fuel can be easily shoveled into the stacks and up the chimneys without generating steam. These things are not sufficiently considered by owners of steam plants." He then described some intermediate dampers near the stoke hole door on the steamship City of New York, which shuts off each furnace before the door is opened, thus preventing any ingress of cold air.

"I think there should be some way found to avoid opening the doors of any furnace—it is wrong to do it; also to have a continued contact of the hot with the cold air, which certainly affects combustion considerably. The rapidity with which a door is opened and closed is very important. There are many elements to be taken into consideration by an intelligent engineer. The uniformity of firing is an important matter, as also uniformity of feed water; cleanliness of the fire; the grading of all the operation according to the kind of fuel and the draught, and the steam to be generated. The engineer should master all these points and then hand them down to the consideration of the fireman, who may be only brute brawn and muscle, but who is capable of earning a little more money, and saving much to the owners."

Mr. J. A. Seely added: "I thoroughly agree with the gentlemen on the subject of the intelligent fireman; but I would like to know where we are to get him. I think we have had more trouble in the electric light business with engineers and firemen than the mechanical lines have. I really believe there is a large field for an intelligent lot of men who will follow the occupation of fireman. We pay our fireman a very good salary, and he has been so successful in the economies of his work that we will raise his salary if he keeps on." Regarding the effect of paying the firemen better wages, Mr. Peck said:

"We were paying $1.75 a day to our firemen, and we expected them to work 12 hours a day, every day in the year, without vacation. We now pay them $2.25 a day, and give them a week's vacation in the summer. In looking over records I find that where we were using 2 $\frac{75}{100}$ lbs. of coal per hour per lamp, we are now using 2 $\frac{51}{100}$ lbs. I do not know whether it is due to improved firing, or whether we have got to a more economic point with our engines. I believe, however, that the additional wages has brought about this result."

Several members gave figures showing the wholesome effect of giving the fireman a pecuniary interest in the amount of coal saved, a plan adopted by several corporations.

To a question Mr. Hammond answered that the depth of fuel upon grate bars from which he gets the best result for either anthracite or soft coal was about six inches. In the conclusion of the discussion Judge Armstrong suggested that it might be a good plan for the association to organize a bureau of firing.

*A paper read at the Buffalo Convention of the National Electric Light Association, Feb. 25, 1892.

Municipal Franchises for Quasi-Public Corporations.*

BY ALLEN R. FOOTE.

I believe that an American economic system is as necessary to American industrial independence as was or is an American political system to American political independence.

The particular feature of foreign economic systems to which objection may be incidentally made in this paper is state or municipal ownership of industries. Those who advocate such a policy in this country are wrongly educated foreign socialists and college professors who have been educated abroad.

It is fortunate for you and myself that we have heard from Mr. Erastus Wiman on the subject of "Electric Lighting from a Financial Standpoint." He has been able to show why the stocks and bonds of electric lighting companies are worthy of being a preferred investment by the ablest financiers. I can tell you at once why they are not. It is because there is a flaw in the title deed under which they are doing business.

A franchise is the title deed upon which quasi-public corporations are founded. A perfect franchise should legally contain every provision that is essential in a deed to real estate, every provision that is required to establish the rights of property, every provision that maintains the rights of free labor.

Men group themselves into municipalities for the purpose of securing industrial, commercial, educational and social advantages. The particular advantage enjoyed in the most marked degree determines the controlling character of the municipality. The advantages principally sought have been, and are, industrial and commercial. These considerations led to the founding of municipalities wherever natural water-powers, water-ways and harbors could be found. When a municipality has been founded where some advantages can be obtained, not possessing all, the inevitable tendency is to seek to secure by artificial means the advantages in which it is deficient. Man's first industrial need is the use of the mechanical power that he controls. To supply this want it is absolutely necessary that natural forces be utilized.

The production, transmission, subdivision and cost of mechanical power determines the number of persons who can use such power *with a profit*. The number of persons such users of power are able to employ with profit determines the number who can enjoy *the rate of wages* the utilization of mechanical power enables such employers to pay. Cost of power is the determining factor. The lower this cost the better the opportunity for making a profit. The more certain a profit becomes the greater will be the number of persons employed.

The municipal needs with which we may now deal are the production, transmission and subdivision for use of a supply of good water, gas and electricity for the production of light, heat and power, the electrical transmission of intelligence and the transportation of persons and property.

Properly to supply these needs, it is necessary to create quasi-public corporations, and grant to them franchises giving them the right to construct, maintain and operate the necessary works, and to construct, maintain and operate through the streets and alleys the necessary street and service connections to enable the service to be supplied to every building in the municipality. How properly to secure such advantages is a question requiring clear perception, broad views, and an entire absence of prejudice, or interests that tend to sway the compass needle by so much as a hair's breadth from the true point of direction, and a calm, unyielding judgment.

The correct settlement of this question will render a great service to industry, the prosperity of wage-workers and the betterment of society. Since the ignorant cannot become the equal of the intelligent except by becoming intelligent, or the poor cannot become the equal of the wealthy except by becoming wealthy, the surest means they can use to assist them in securing these objects is to co-operate with the intelligent and wealthy in organizing corporations for the supply of quasi-public services and the conduct of private industries. It is by means of such corporations that labor can receive the most intelligent direction, obtain the use of the most efficient tools and realize the highest degree of profit.

A supply of water is a perpetual municipal need. The best interests of its users demand that the supply shall be abundant, wholesome, and that it shall be furnished at the lowest possible price.

A means of producing light, heat and power for public and private use, distributed from a central station, is a perpetual municipal need. The best interests of its users demand that such means shall be abundant, wholesome, reliable and safe, and that it shall be furnished at the lowest possible price.

A means for the electrical transmission of intelligence is a perpetual municipal need. The best interests of its users demand that such means shall be quick, accurate, reliable and safe, and that it shall be furnished at the lowest possible price.

A means of inter-municipal transportation for persons and property is a perpetual municipal need. The best interests of its users demand that such means shall be rapid, reliable and safe, and that it shall be furnished at the lowest possible price.

Had laws governing the organization, management and control of municipal franchise corporations been enacted in accordance with the requirements of true economic conditions, instead of in compliance with the dictates of an unintelligent self-interest or prejudice, how great the change in their wording and meaning would be. There would have been no reference to a particular source, force or instrument, such as gas, telegraph, telephones, electricity or horses, *The character of the need to be supplied, not the character of the method of supplying it, would have determined the designation of the work to be done.*

So rapid and so radical have been the industrial changes wrought by a growing intelligence, encouraged by the acknowledged freedom and dignity of labor, facilitated by the right of private initiative, driven by the energy of hope, inspired by the certainty of owning the profit of the risk incurred, that in a single decade the methods in use at its commencement become obsolete before its close. As a result, the strongest barriers to progress that now exist are the limitations placed on municipal franchise corporations by legal specifications defining the methods to be employed instead of the character of the need to be supplied. The wisdom of the fathers was not equal to our own. All such barriers must be brushed away.

What would be the thought of persons who would undertake to secure improvements for a city in the form of buildings of the largest dimensions, employing the most durable material and the best style of architecture, by offering a title to real estate on which the buildings were to stand that did not guarantee exclusive possession and perpetual tenure? The moral and economic sense of the community would be shocked by such a proposal. Yet there are persons in every community who will contend that works costing more than the best buildings in the city, which, if operated under true economic conditions, will inevitably enhance the value of all inter-municipal real estate more surely than any other factor of modern civilization, shall have no better title than the one indicated.

How strange it appears in the light of the requirements of true economic science that municipalities have supposed they could obtain a supply for a perpetual need, requiring expensive plants, conductors through all streets, service connections to make the supply available in every building, and have the service wholesome, reliable, safe and rendered at the lowest possible price, in the way in which they have undertaken to secure these advantages.

They have limited the right to do business to a comparatively short term of years. They have allowed others to build, as it were, on the same piece of real estate. They have limited the methods to be used so that, when the discoveries of science and invention have made better methods available, existing corporations could not use them, thus compelling the organization of other corporations and a duplication of plants.

The services rendered by municipal franchise corporations are assistants to industry, promoters of comfort, and inducers of prosperity. Any unnatural restriction placed on them is as fatal to the welfare of society as an unnatural obstruction to the inhaling of air or taking of food is to the health of the physical body. Any tax levied upon them is as fatal so the best interests of industry as the extraction of blood is to the physical strength. Obstructions and taxes laid upon quasi-public services are like rust upon a plow or a hole in a grain sack. They narrow the depth of the soil turned and lessen the quantity of seed to be sown. As the value of the harvest is greater than the seed, so is the value of the cheapened service greater than a tax that enhances its cost.

A perfect franchise is the exact equivalent to a perfect title to real estate. It conforms fully with the conditions that give economic value to all property. It is in accord with ethical and economic laws that proclaim and establish the dignity and freedom of labor. It conveys and guarantees unrestricted, exclusive and perpetual possession, subject to such use and control as shall best serve the public welfare.

A condition of vital importance to wage workers, in the discussion of a question of this kind, that cannot be urged upon their attention with too much force, is the fact that every time an industry is removed by legislative enactment from the list of self-producing industries and placed in the list of non-profit producing industries operated under government ownership, an avenue to industrial independence is closed. Profit-producing industries are avenues to industrial independence and economic freedom for all who are engaged in them. For the wage-workers, more than any others, the self interest of the individual, the moral interest of society, the group interest of the municipality, state and nation, demands that *all avenues to industrial independence and economic freedom shall be kept open.*

In the discussion which followed Judge Armstrong said: "I do not feel like discussing this paper, for the reason that there is so much of it, and there is really so little with which we can theoretically disagree. I do not mean to say that it is impracticable. It may be possible to get all the citizens of the state to join together with all the stockholders of a corporation, and in looking only to the best interests of the body politic you could, possibly, get such a consensus of opinion and agreement as would be willing to give eternal life to a corporation to do things eternally demanded. There is no reason why one electric light company should not furnish all the electric light needed in a given city, but we are so constituted that, just as sure as that was the case, notwithstanding the fact that the company might be under government supervision, and its affairs open to inspection at all times, there would always be the question raised whether it could not be better done under this, that or the other circumstances. I question if this theory comes to be strongly advanced, whether there may not be a more urgent demand that the municipality itself engage in all these things that are of a practically public nature. When we say you cannot do it as cheaply, the inquiry is made, why not? We have had this question discussed in our meetings before, and we know that there are so many elements entering into the question of municipal electric lighting that it cannot be done as cheaply as by private enterprise. We are anxious to furnish at the cheapest possible price this form of city lighting which has become a necessity and so great a factor in our modern civilization; we are willing and anxious to make the cost of production less and receive only a fair profit, and give the service to the people as cheaply as we can. When we can get the people to properly understand this question from a commercial standpoint, we shall have no difficulty in obtaining renewals of our franchises, so that they shall be practically perpetual, and the advantages set forth by Mr. Foote's plan will be gained in that way; but we cannot do it by government work, by law; we must do it by the education of the people."

Mr. C. E. Scott added: "I agree with Judge Armstrong in all he states. I think it is only by the education of the people that we can do anything. The tendency of legislatures has been steadily toward removing restrictions when granting charters to electric lighting companies.

*Abstract of a paper read at the Buffalo Convention of the National Electric Light Association, Feb. 25, 1892.

This has certainly been the case in my own State. It strikes me that this Association should be the great educator of the people. I have seen professional men take up our electrical journals and read them with a great deal of interest, and especially the proceedings of this association. I have seen professional men at our meetings in Cape May and Montreal, and I have seen them here, who have nothing to do with electricity, and I ask them why they are here, and they say it is a subject of great interest. One lawyer told me that he was apt to have a case one day, and he wanted to know something about the matter. These men take an interest in us, and everybody takes an interest in the subject, and it is for this association to be the educator of the people. Let all the central station men in the country that can possibly come here do so; let them rub against each other and disseminate their different views. Let us have that kind of organization which will make us a power to be felt, and then it won't matter much what kind of a charter we have. If you once have yourselves properly understood you will have no difficulty in holding your position; you will be like the Bell Telephone Company when its patent expires—it will keep its customers. If electric light companies give to their customers the best article obtainable at a reasonable price they will be able to go right on; there will be no danger of anybody else coming in, for there is not enough margin of profit in it."

Alternate Current Motors.*

BY WILLIAM STANLEY, JR.

It is not my purpose in the present paper to enter minutely into the details of the various attempts that inventors have made to produce an operative motor. The historian who shall collect the data necessary to trace the rise and growth of the alternating current motor will find that the subject has been pursued by men of science in all parts of the civilized world, and he will be obliged to chronicle the fact that, up to the present year, no thoroughly practical motor system has been worked out. The various plans suggested by inventors and by engineers may be classified into three types; they are: First, motors operating in synchronism with the current alternations, having a field magnetization, produced by continuous currents with alternate currents applied to the armature circuits, a type originally demonstrated by Hopkinson in 1883; second, motors actuated by the inductive effects of a rotating field upon closed armature circuits, first suggested by Mr. Tesla in 1887, and, third, motors operated by alternate currents, in both field and armature, constituting one of the types investigated by Mr. Kelly and myself. As far as I know, the first work on alternate current motors in this country was undertaken at Great Barrington, 1886 and 1887, when I designed and built a synchronous motor, and a motor acting under the repulsive currents obtained by periodically short circuiting armature coils while they were under induction from the field. One of these motors was designed in January, 1886. Professor Thomson, in 1887 and 1888, also produced motors of this type, and what was of still more importance, he read a paper before the Institute of Engineers memorable for the clearness with which he treated the subject.

In order to more clearly explain the troubles found in designing

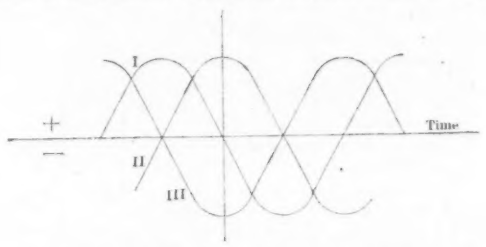


FIG. 1.—STANLEY ON ALTERNATE CURRENT MOTORS.

these and other alternating current motors, I wish to call your attention to two of the properties possessed by circuits traversed by alternate or variable currents. When dealing with continuous currents we are accustomed to consider that the resistance of a circuit is determined by the area and length of the conductor and by the specific material composing it. In dealing with alternate currents, it is desirable to extend the definition of the term "resistance" to a fuller meaning. The term "resistance," as you all know, is that property of a circuit which determines the amount of electrical energy disappearing per unit of current, the value of this property or "resistance" being obtained when the energy in circuit is divided by the square of the volume of current flow.

When steady currents occupy a circuit, the resistance value is confined to the conditions which exist within the conductor, viz., the "resistance" is proportional to the length of the circuit, inversely proportional to its area, and dependent upon the kind of material employed. When variable or alternate currents are applied to a circuit, the resistance proper may not be confined to the interior of the conductor, but may extend to its surrounding neighborhood, for with these changing currents work may be done outside of the conductor as well as inside of it, and, as the losses by hysteresis and by induced currents cause a disappearance of electrical energy, they may be defined in terms of the current flowing and a resistance factor. When alternate currents are used, this factor is always greater than when steady currents flow, and while in particular cases the disappearance of electrical energy taking place outside of a conductor may be small, there are cases in which the energy lost outside far exceeds the loss within the wire itself. Another point may be noticed. We are accustomed to think of the resistance of a wire as a fixed quantity; we say, a circuit has ten ohms resistance, and we are in the habit of thinking that this value of ten ohms is approximately constant and independent of the current flow. While this supposition is true for steady currents, it is not true for those of changing value. If the conductor carrying an alternate current is of small section, less than one-quarter of an inch diamater, the internal resistance of the circuit remains nearly constant for alternate currents of the frequency we are accustomed to handle, while the external resistance, if I may be allowed to use such a term, increases with an increase of current and may increase as the square of the current, or faster. While I am aware that this treatment of the term "resistance" is not in ordinary use, yet it is quite orthodox; it has been defined by the mathematicians, and its use may be justified, as it is often instructive in comparing the losses taking place within and about a conductor occasioned by the flow of alternate currents. In designing alternate current motors, for instance, the loss of energy exterior to the circuits has to be very carefully watched; for example, an alternating motor armature wound in the ordinary manner might carry one ampère of current with very little loss other than that due to its interior or ohmic resistance, while ten ampères might cause a loss exterior to the wire by hysteresis and eddy currents several times the ohmic loss in value, or the exterior resistance

*A paper read before the Buffalo meeting of the National Electric Light Association, Feb. 23, 1892.

might become so great as to practically prevent the flow of current to the value desired.

The other property of a circuit carrying an alternate current, to which I wish to allude, is its so-called inductance, which is the property of inducing upon itself an electromotive force. The electromotive force thus produced combines ith the other electromotive forces in circuit to determine the direction and value of the current at any time. It is not necessary for the purposes of this paper to trace out just why or how it happens that these electromotive forces are developed, or why they do not coincide in phase. By looking at the printed sheet, Fig. 1, you will find the diagrams which illustrate the phase differences of these electromotive forces; that marked I is the electromotive force in a circuit which urges the current against the resistance of the circuit whether the resistance be within or about, or both within and about, the conductor. The curve marked II indicates the relative position or phase, that is, time of flow of the electromotive force of self-induction, which, as you see, is to the right of the first electromotive force, and, lastly, you will find the phase of electromotive force developed upon a condenser when attached to a source of alternate currents.

For the present it is only necessary to notice that two of these electromotive forces, II and III, have their maximum and all corresponding values at the same time, as, for instance, at the time *C*.

$$\sqrt{(\text{Applied E.M.F.})^2-(\text{E.M.F. of Self Induction})^2}=CA$$
$$\sqrt{(300)^2-(250)^2}=165 \text{ volts}$$

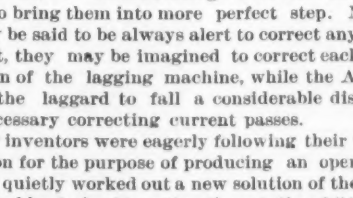


FIG. 2.—STANLEY ON ALTERNATE CURRENT MOTORS.

II and III are opposed in direction, *A* being + direction, *B* being — direction, while the maximum value of each falls upon the same time line.

Let us now briefly examine the various types of motors that have been suggested, and which I have classified in three types.

It is well known that if an alternating dynamo be run until its speed of alternation or frequency is approximately the same as that of the generator from which it is to be supplied, and if its field is properly magnetized, it can be coupled to the generator by simply closing a switch; it will then fall into step with the generator, and will take load and behave in a very proper manner; the trouble is to get it into step without employing costly or complicated appliances. If one attempt to start such a machine by commutating the current in the ordinary manner, he will find that the current will refuse to flow in the field circuit, the inductance of the circuit keeping most all the current out. How to start a synchronous motor is a problem still unsolved, but Mr. Kelly and myself believe that we have found a solution.

It is not to be understood that all dynamos will run as synchronous motors with equal satisfaction, for while the machines made in this country will so run, they are not to be compared for this or multiple connected service with the Mordey machines made in England, which, by the way, I consider to be the best designed alternators yet produced. The reason why the Mordey machines excel as synchronous motors is, that the inductance or self-induction of the armature circuit is so low that the slightest tendency to fall out of step is instantly corrected by the necessary current flowing in the armature.

If one attempt to couple two or more of our American alternators in parallel (I refer to surface wound machines), he will find that a large false or useless current will surge to and fro between the armature circuits; this false current is due to the fact that when two alternators are put in parallel there are always short intervals of time during which one machine leads and does work upon the other. This interchange of current between the machines tends to bring them into more perfect step. Mr. Mordey's machines may be said to be always alert to correct any difference of phase—in fact, they may be imagined to correct each other at the first intimation of the lagging machine, while the American machines allow the laggard to fall a considerable distance behind before the necessary correcting current passes.

While many inventors were eagerly following their various lines of investigation for the purpose of producing an operative motor, Mr. Tesla had quietly worked out a new solution of the problem on an entirely novel basis, by inventing the rotating field, that is, the field produced by shifting magnetism, and producing it by alternate currents. Mr. Tesla's motor is so simple and so beautiful in theory that many have doubtless wondered why it has not been brought into general use. If I correctly understand the subject, it has not been commercially adopted because of the difficulties in operating it at the frequency generally in use in this country, viz., 130 ~ p. s., and especially because thus far special generators and circuits having phase differing currents must be employed. There have been many attempts to subdivide alternating currents into two or more currents differing in phase. Special arrangements of condensers for producing phase differences from a single source of supply have

$$R=\frac{\text{Watts inside of wire + Watts outside of wire}}{C^2}$$

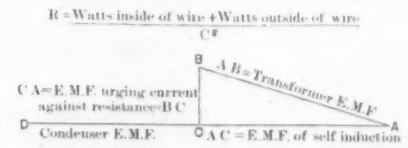


FIG. 3.—STANLEY ON ALTERNATE CURRENT MOTORS.

been worked out by M. Leblanc in France and by Mr. Kelly in this country. As regards the motor itself, there are two drawbacks to its use which have not thus far been entirely removed; they result from the inductive effects of the currents upon themselves and upon each other.

To understand this matter in a practical sense, let us assume a Tesla motor having 300 pounds of iron in its field and armature to be magnetized; suppose it to be supplied with a 16,000 alternate current at 300 volts pressure. We have 300 volts then applied to each of the two field circuits. We can count on the motor being magnetized to at least 20,000 C. G. S. lines per square inch of iron, which, with a loss of one watt per pound in hysteresis would then represent an external resistance loss that is a loss outside the wire, of 300 watts, and a resistance of $\frac{300 \text{ watts}}{C^2}$. In this case the internal resistance of the copper coils may be made low and may be neglected.

Now, it is evident that the magnetization produced in the field will react upon the field coils and will develop an E. M. F. of self-induction, and this E. M. F., as shown in Fig. 1, will be 90 degrees, or half a semi-period from the E. M. F. urging the current against the resistance; let the value of this induced E. M. F. be 250 volts, then the E. M. F. urging the current against the resistance will be found by

$$\sqrt{(\text{applied E.M.F.})^2-(\text{E.M.F. of self-ind.})^2} \text{ or } \sqrt{300^2-250^2}$$
$$=165 \text{ volts.}$$

That is to say, that of the 300 volts applied, 165 volts are used up in urging current to magnetize the motor when it is doing no work, and 250 volts are available for inducing currents in the armature. If, as we have assumed, the loss due to hysteresis is 300 watts, then the current flowing would be $\frac{300 \text{ watts}}{165 \text{ volts}} = 1.8$ ampères, and the resistance external to the wire $\frac{300}{(1.8)} = 92$ ohms.

I do not mean to say that these conditions are actual or cannot be improved; they ought to be. I present them simply to show that, with this type of motor, the full E. M. F. employed is not available, as in the example when, with 300 volts applied, but 250 volts are available and 165 volts are lost.

Moreover, it is necessary that a strong field magnetization should be developed in a motor in order that a powerful starting torque may be had; as a consequence, the field circuits of this motor must be composed of a comparatively *small* number of turns of wire (the flux or magnetization in an alternating magnet being inversely as the number of turns with a given applied E. M. F. and with a magnetic circuit of given reluctance). It might also be shown that the value of the field producing current in these motors, viz., the current required to run the motor empty, is largely dependent upon the air gap between the field and armature, the current at no load being greater as the clearance between the field and armature is increased. The Tesla motor then must necessarily have a false or lagging current at no load, and must expend considerable energy in the production of the rotary field by hysteresis loss, until some one, and Mr. Tesla as likely as any one, shall find an iron without hysteresis and an air gap that does not require magnetomotive force. I understand that these motors require about .6 of the full load current when running free with a factor of lag of about .7, so that the actual per cent. of energy required to run them free is, approximately, $.6 \times .7 = 42$, or, say, 40 per cent. of their full load energy. This is a rather serious matter when viewed from the standpoint of the station manager, for if the motor service requires .6 of its full load current to run free of work, then evidently .6 of the station capacity must always be in operation. There is another slight trouble with these motors, resulting from the fact that the co-efficient of mutual induction does not keep up as the motor is loaded: this may be explained by saying that the flux and, consequently, the E. M. F. developed in the short circuited armature coils, decreases as the motor is loaded; this decrease of induction affects the speed of the motor, causing it to fall off with load, while it requires a larger current in the field to furnish an increased amount of work; both of these difficulties, however, are very largely determined by the design and calculation of the motor itself, and may be brought within working limits. I see no reason why this motor may not be made successful and operative by proper designing and careful study.

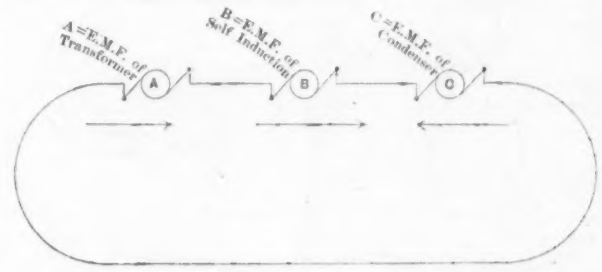


FIG. 4.—STANLEY ON ALTERNATE CURRENT MOTORS.

The problem before those studying the alternate current motor is, however, entirely independent of these difficulties. Had we a reliable means of dividing an alternate current into two currents having the proper difference of phase, Mr. Tesla's motor would be made available and would be of great commercial value. Mr. Kelly and myself have found an entirely novel and complete solution to the problem. As far as we can discover, it has never been attempted by any other experimenters. By the use of a very simple invention, we are able to draw from a single transformer secondary two phase differing currents, having any differences of phase we elect. These currents maintain their phases, that is to say, times of flow, independent of the ampèrage of the current and of each other. We can apply our invention at the station, splitting the primary current from the dynamos into two phase differing currents, or we can lead the primary current through a transformer and split the secondary into two components.

I regret that I am unable to disclose the methods we adopt, but I hope to be able to publish our results shortly. Our method will then allow us to run the Tesla motors from the same circuits and by the same generators that we now employ in incandescent alternate current lighting. The Tesla motor for the past five years has been waiting for one thing only to develop it, viz., a current splitter, and we have found one.

Mr. Kelly and I have invented what we call a "condenser motor," which differs radically from either of the above mentioned types. The problem which we have had in mind was to construct a motor which should be operated by existing alternate currents in exactly the same manner that we operate an ordinary motor when supplied with continuous currents; to do this, it is necessary to construct a motor whose circuits do not possess (effective) self-induction, or, to put it in another way, it is necessary to take away from the alternate current circuits the effects of the E. M. Fs. induced in them by their own currents, which renders unavailable a considerable part of the E. M. F. applied.

I will attempt to explain our shunt motor without the use of formulæ, illustrating the results obtained as best I can.

Our motor has a laminated sheet iron field, and may be made in any of the multipolar or bipolar types. The field winding is connected in series with a condenser to the secondary of a transformer, which, when fed from the station, furnishes the source of supply. The armature of the motor, although wound with a special winding, is substantially the same as a continuous current armature, and is surrounded by closed copper bands whose function I will describe later. The theory of the motor is, that, given the necessary magnetization and armature current, the motor will operate as well with alternate as with continuous currents. Returning to the field circuit, let us glance at the function of the condenser. If the field windings were connected directly to the transformer or source of supply we should have two E. M. Fs. in circuit, combining to oppose the E. M. F. applied by the transformer. Let the line *A–B*, Fig. 3, be this E. M. F., and let *B–C* be an E. M. F. whose value is found by multiplying the current (in the case assumed) by the resistance of the circuit. By resistance is meant the internal or ohmic resistance plus the external resistance due to hysteresis and eddy currents, then *A–C* is the E. M. F. of self-induction; the two E. M.

Fs., A-C and B-C, combine to always just balance the transformer E. M. F.

Now, in any operative type of motor, the E. M. F. A-C will always be greater than B-C, or simply the opposition of A-C will be so great as to practically obstruct the flow of current in the field. If, now, we could introduce a third E. M. F., such as C-D, which should always oppose A-C, we could neutralize the effect of A-C upon the time of flow and value of the current, which, in that case, would not be opposed by any E. M. F., except C, R, or $C = \frac{E}{R}$, as in the case with steady currents.

To get this third E. M. F., we insert a condenser whose capacity is so chosen that the field current will develop a potential upon the condenser terminals equal to the E. M. F. A-C; if the field current changes in value from time to time, it will change the values of both A-C and C-D (as these E. M. F's. are in series connections) in almost the same ratio, and consequently these two E. M. F's., the one on the condenser and the other on the field coil, will always neutralize each other's effects, and the circuit will be left free to the current flow, as with continuous currents. Perhaps this may be made simpler by considering the resultant effects produced by a number of alternators coupled in series, Fig. IV. Let A, B and C be these generators; let them be all rigidly coupled to the same shaft, A being set on the shaft so that its armature generates an E. M. F. 90 degrees away from that of B and C, while B and C are coupled to produce the same voltage at the same time and have their terminals opposed; then B and C will exert no effect upon the circuit, for they will always neutralize each other. The E. M. F. of A corresponds to the transformer E. M. F.; the E. M. F. of B to the E. M. F. of self-induction on the field coil, and the E. M. F. of C to the E. M. F. on the condenser. In this way we obtain the necessary current to magnetize our motor unrestrained by the E. M. F. of self-induction.

The next difficulty to clear up, in order to operate our motor, is to get rid of the external resistance in the armature circuit. In order that a motor may operate economically and regulate properly for changes of load and current, it is desirable that the armature resistance should be very low; the principal resistance offered to alternate currents in an armature is, as before stated, due to the work outside of the armature wire in the iron core; these losses in the iron are occasioned by the alternating magnetization developed by the armature current; to remove this loss of energy we have had to destroy most all of the armature magnetism in the following manner:

You are all aware that if a magnet core is wound with two equal coils in opposite directions and is connected with a current source, the resulting magnetism will be only that due to the difference of the winding displacement, and will be practically negligible. About our armature, see Fig. 5, we place close circuited copper bands or wires, so disposed as to be parallel to the direction of current flow in the armature conductors; the currents flowing in the armature windings induce oppositely directed currents in the stationary bands, and, consequently, the armature core is surrounded by two

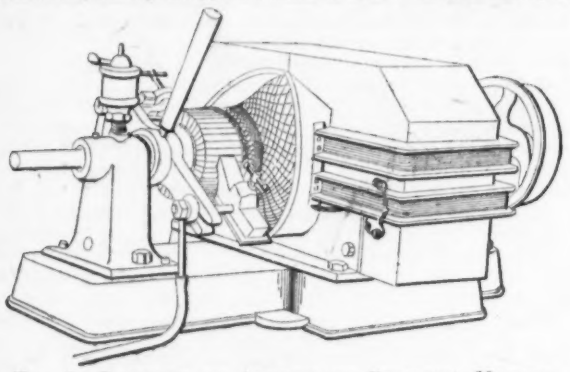


FIG. 5.—STANLEY ON ALTERNATE CURRENT MOTORS.

sheets of current during each wave of current flow; the sheet of current on the armature flowing in one direction, while the current in the stationary bands flows in the opposite direction, thus practically preventing any magnetizing effect, and thus, also, preventing any loss by hysteresis and eddy currents in the core. Now, it can be shown that the work lost in the copper bands will be very small, providing the resistance of these bands be kept low, and we have found that this loss can be made as low as one-third of the inside or ohmic loss, a result which enables us, by proper designing, to make our armatures almost as efficient as those of the best direct current type, with small aditional expense.

One other point of advantage obtained by the use of the compensating bands should be mentioned; as the cross magnetization of the armature is practically destroyed there is no change of lead under variation of load as there is no distortion of the field magnetism by the armature current. These results are eminently satisfactory. In describing the Tesla motor I pointed out that there was a loss of voltage, or that, of the voltage applied, a considerable portion was unavailabie; in our motor 96 to 98 per cent. of the voltage applied to the armature is available, while the operating conditions are identically the same as found with a continuous current motor. It is not to be understood that the motor has an efficiency of 96 to 98 per cent. Far from it. In our small motors (⅛ and ¼ h. p.) the losses in the field and armature will aggregate 30 to 40 per cent. In the larger types of from 2 to 5 h. p. the loss will not exceed 25 per cent., while in the still larger sizes the losses will be much less. The problem of the efficiency of the motor is almost the same as the efficiency of the transformer and depends in large measure on the care and skill of design.

To operate our motors it is necessary that the speed of the dynamo should remain constant; as constant as possible. If the stations will give us a definite number of alternations, and will maintain that number, our motors will behave beautifully; if the alternations change, the condenser E. M. F. will no longer exactly oppose the lagging E. M. F. of self-induction and the field current will change and lag either positively or negatively; mere change of E. M. F. will not interfere with the operation of our motors more than it would with any continuous current motor.

Fig. 6 illustrates the general design arrangement of the motor system. The condenser is placed either upon the wall or under the motor in the base; the E. M. F. applied to the field is about 150 volts; the armature E. M. F. is either 50 or 10 volts. The E. M. F. on the condenser is, approximaetly, 750 volts; while this E. M. F. may appear excessive at first sight there is no real danger from its use, as a contact across the terminals would instantly reduce the potential and accidental contact is easily prevented by properly insulated wires.

There is one other type of motor to be mentioned; the series wound motor. When operating any of the ordinary types of motors by alternating currents, it is necessary that the phase of the field magnetism must coincide with the phase of the E. M. F. applied to the armature circuit, that is to say, the field magnetism must arrive at its maximum value at the same instant the M. F. applied to the armature arrives at its greatest value; for if these two values do not coincide in time, the counter E. M. F. developed by the rotation of the armature will not directly oppose the E. M. F. applied to the armature, but will be skewed off one side, and, consequently, will allow a large false current to flow in the armature circuit. Fig. 7 illustrates the point, for suppose they do not coincide in phase, then A-B represents the maximum value of the alternating E. M. F. applied to the armature, and B-C represents the lagging magnetization, which, as I have stated, should coincide with A-B; consequently B-S represents the counter E. M. F. of rotation, which is, of course, directly opposed to B-C and should be directly opposed to A-B, or should occupy the position of B-E. It can be shown that D-F is the E.M. F. urging the current against the resistance of the armature, or C-R, while E-F, which is smaller than D-F, would be that E. M. F., providing the magnetism B-C coincide with A-B. All this simply

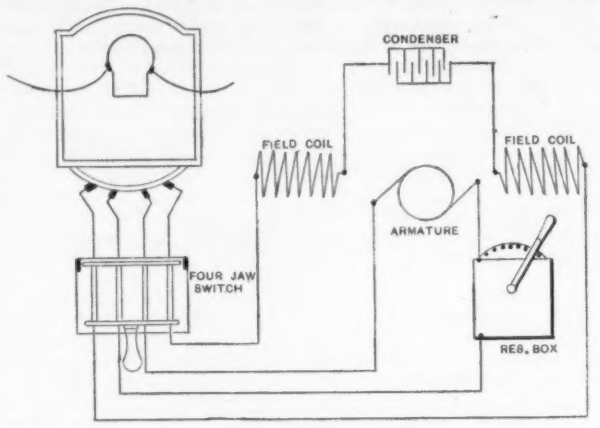


FIG. 6.—STANLEY ON ALTERNATE CURRENT MOTORS.

means that, when operating a motor by alternate currents, the magnetism in the field should coincide with the E. M. F. applied to the armature, or else there will be a false current in the armature circuit; the condenser accomplishes this desired result in the shunt type of motor; in the series wound motor the magnetization necessarily coincides with the armature E. M. F., because they both accompany the same current. The series wound type of motor, then, is the simpler to deal with; let us examine it for a moment. If an alternate current source be applied to a series wound motor properly constructed with laminated fields, etc., the motor will run with feeble torque, and if one investigate the cause of this want of torque and power, it will be found at once to be due to the inductance of the motor; the E. M. F. of self induction will greatly reduce the available E. M. F. applied to the motor, and consequently lower its capacity to translate electric energy into mechanical power. We have removed this deleterious effect of the E. M. F. of inductance in the following manner: Fig. 8 represents a motor having its field and armature connected in series, while c is a condenser also connected in series; the distribution of the E. M. F. is given in the diagram. The transformer supplies the motor with current at fifty volts pressure, the E. M. F. of self-induction located almost entirely upon the field coil is assumed to be sixty volts, the E. M. F. on the condenser is, consequently, sixty volts for the current in circuit and the load on the motor, and, consequently, if the current varies, then both the condenser and self-induction E. M. F. vary in approximately the same manner, thus leaving the circuit to receive current from the transformer and to do work. In my judgment, this type of motor will be of great practical use; not only will these motors successfully handle all constant load problems, such as pumping, blowing, etc., but they will be exceedingly useful in crane and elevator work, while their service in propelling cars can hardly be estimated. In all cases where hand control is required, they can be operated as successfully as continuous current motors.

The most serious question we have met in pursuing this problem has been that of finding a suitable condenser. It may be well to state that none of the ordinary types of condensers, viz., those made of paper, paraffine, glass, mica, etc., are of the slightest use. We have found that the residual charge in all the above mentioned substances absolutely prevents their acceptance; this residual charge seems to depend upon the non-homogeneity of the dielectric and upon the want of an absolute contact between the plates of the condenser and the dielectric surface. When glass is used as a dielectric and a potential of 1,000 volts (average) is maintained upon the condenser, the glass heats rapidly until, finally, it is shattered to pieces. Condensers of glass, when raised to a potential of 15,000 volts, became phosphorescent, rapid flashes of light appeared in various parts of the glass, while they withstood the potential, which

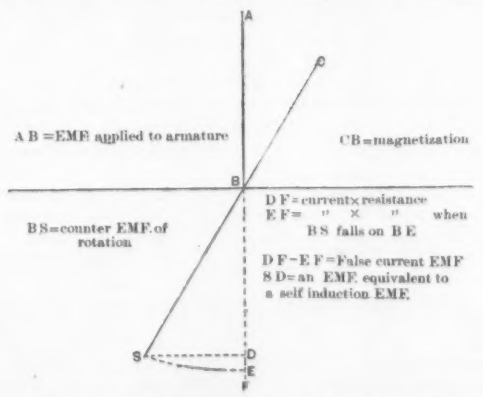


FIG. 7.—STANLEY ON ALTERNATE CURRENT MOTORS.

was only for a few moments. Vulcanite we find unreliable; metallic chips are always present and for this reason, if for no other, it fails to stand satisfactorily. We have succeeded in producing what we call "films" from .003 to .005 of an inch thick, which will surely stand a potential of 1,000 volts. We believe that these condensers are entirely commercial and that they will not deteriorate, while their cost per microfarad is quite low. So perfect are they that they show but little trace of residual charge, they do not heat perceptibly when in circuit for a long time, and withstand a potential of from 2,000 to 3,000 volts with a dielectric thickness of .006 inch. The processes of their manufacture will not be made public at present.

Of the three types of motors mentioned in the beginning of my paper I have but partially described one; the other two can be worked out. We believe we know how to perfect the synchronous type; we expect to do so. The Tesla motor is perhaps the simplest of the three to work out from the beginning, but, like all such problems, it requires study and careful investigation. The so-called multiphase motors, of which much has lately been written, possess no advantage over the two-phase type as devised by Mr. Tesla; in fact, the two-phase motors are neither better nor worse; but the European multiphase motors appear to have been carefully designed; the relations between field and armature seem better, and, if they possess any superiority over the American rotary motors, it is derived from these conditions rather than from any new departure in the application of the three-phase currents.

Mr. Kelly and I have produced motors which are operative on existing circuits. As we have stated, our motors start at full torque, run to a definite speed and behave exactly like direct current motors under load. So perfectly does our compensating winding eliminate the E. M. F. of self-induction from the armature circuit, that this circuit offers very nearly the same opposition to alternate currents of a frequency of 130 ~ p. s. that it offers to continuous currents; there is, therefore, little falling off of speed due to the self-induction of the armature circuit; in fact, we can over-compound the motor by its own load by setting the brushes off the neutral point of commutation, thus changing the flux through the field.

Your president has asked me to address you on the alternate current motor problem, and I presume he expects me to offer an excuse on behalf of the profession for not having placed in your hands a perfected motor adapted to your circuits before this time. I can only say that the problem has been a difficult one; there are so many opportunities offered to alternating currents to dissipate their energy, so many more than are found with continuous currents, that one has to be very keen sighted to avoid undue waste in constructing alternating machinery, but, from the knowledge already acquired I feel convinced that the coming year will place the alternate current motor firmly on its feet, and that before the year elapses many stations represented in this convention will be testing the accuracy of the statements contained in this paper.

In the discussion Mr. Stillwell asked whether in this motor there is any retardation of the currents behind the E. M. F. in the circuits? Supposing there was a long line over which the power was transmitted; what would be the relation of the phases of E. M. F. and current in the circuit from the generator to the motor? In replying, the author stated that there was no retardation whatever, that is, the E. M. F. flowed at the time of the impress of the E. M. F. "There is no lagging, and therefore there is no false current. The product of the current into the E. M. F. expresses the true energy. In all of the rotating field motors, if you want to find out how much power you are using, you must multiply the product of the E. M. F. and current by some decimal, some factor, which gives you the relations of the power actually absorbed to the power apparently absorbed; in our motors it is not so."

Mr. Stillwell, who has undoubtedly had a wide experience with the Tesla, or rotary field motor, agreed with the statement regarding the lag, but stated that it depends very

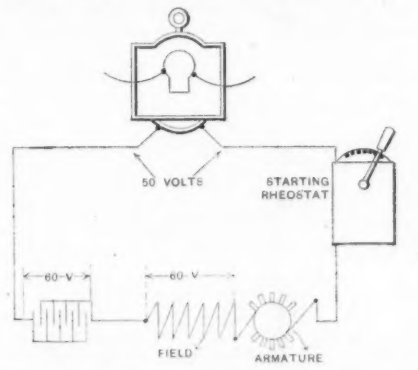


FIG. 8.—STANLEY ON ALTERNATE CURRENT MOTORS.

much on whether it was running with full or with light loads, and that it behaved very much like a transformer. The perfection of this motor depended greatly on the careful study of details of construction.

"Mr. Tesla and Mr. C. L. Scott have worked on this subject for a long time, and have brought the Tesla motor up to about the best relation that I believe is practicable with that type of motor, and that is a very good relation for certain purposes. The relation of the false current at no load is not, however, proportionate to the energy. In a transformer of the closed circuit type, when no lamps are burning on the secondary circuit, and consequently no currents in the secondary coil, we can obtain the true energy in the primary by multiplying the current and E. M. F. by a factor, which, for the types ordinarily used in this country, is about .7. As lamps are added to the secondary circuit, the phases of E. M. F. and the current in the primary tend to coincide, and at a partial load, comparatively small, they do coincide, practically, so that the product of current and E. M. F. shows the true energy. In the Tesla motor, the same general relation exists, and if it were possible to operate the motor without an air-gap, identically the same relation would exist. As we load the motor, the phases (the applied E. M. F. coming from the generator and the current) tend to coincide; and while on a motor of 15 h. p., which gives about the best results, at no load we must multiply the current and E. M. F. by two-tenths instead of six-tenths; at full load we would multiply it by eight-tenths or nine-tenths; that is to say, that when a Tesla motor is turning over, the false current is very large, but there is a relatively good regulation as to energy. Good current regulation is very difficult to obtain, and therefore there is always some flow in the circuit. This does not apply to the efficiency, and the false reading is by no means as great as would be understood from the bare statement."

Regarding Mr. Stanley's new motor he said: "When he is ready to disclose his method, we shall be in a position to say more definitely what it will probably do. At the present time it seems to me that the practical question presented is this: Assuming the case of power transmission for a considerable distance, and omitting for the time reference to the very general application of such a motor on existing circuits of small size, I think it is very questionable whether the advantages over the multiphase or synchronous type would be real. We should certainly have to pay some price for it, by using some new apparatus, a condenser or something else. If we were to transmit power from Niagara Falls to Buffalo, and were to use existing apparatus—about as good method as we could use—we could have two satisfactory methods, one the two phase or multiphase system and the other would be the straight synchronous system, with small starting motors to start the large ones. I think if we were called upon to supply power to Buffalo from Niagara Falls

it would be a toss between the two methods. It would depend largely upon the amount of power to be transmitted and the potential to be employed. If it were 10,000 volts it would be sufficiently high for a distance of 30 miles for not more than 2,000 or 3,000 h. p. It is probable that we should prefer to use two wires and two sets of insulators on each pole rather than to run three or four wires. The advantage of the latter would be that we could start the motors with torque, so that they could be brought up to their full speed when fully loaded. The disadvantage of the synchronous system is simply that starting devices must be used; but that is a small matter and a small portion of the necessary investment. The multiphase and the synchronous type, when run at full load, should be operated synchronously. I do not think there can be any doubt as to that. If we do not operate them synchronously there is sure to be a retardation of current behind the E. M. F., and the effect of that is to multiply or increase our investment in copper. Synchronism is a decided advantage, which should not be overlooked. A synchronous motor will run at a speed absolutely equal to that of the generator, irrespective of load. It will not get out of step if properly designed, unless overloaded to the extent of 100 per cent., an occurrence which is extremely improbable. If it should happen, it is easy, by means of an automatic cut-off, to protect the motor. For small motors, supplied from ordinary alternating current circuits as they now exist, a motor such as Mr. Stanley describes would have a very extensive, and I think, very valuable application. There are motors which can be used for this purpose, but there are some objections to their use. The ordinary synchronous motor can be made self-starting without great torque, but with sufficient torque to bring itself up to speed. You will remember that the commission of distinguished engineers who considered this matter in connection with the proposed plant for the city of Frankfort, arrived at the conclusion that the ordinary synchronous motor, started with small torque, and without load, was a practical and sufficiently effective motor for general purposes; and the views of the commission were in favor of the alternating current, even as against the direct current, for a comparatively limited area. The only objection they raised to this system was that there was a certain amount of sparking at the commutator. As I have seen one of those machines in operation it may be interesting to know how far it has been improved since. At that time Zippernowski was using the copper brushes, and starting the motor at low speed. The product of the revolutions and the number of poles of course did not equal the number of phases at the low speed, and there was sparking. The Frankfort commission undertook to measure the amount of copper that was detached from the commutator by sparking one hundred times. Since that time we have very generally taken to carbon brushes; and the carbon brush applied to that motor practically gets over that difficulty. I have seen this synchronous motor start on a high number of volts, without any sparking that would cut the commutator. There is a slight discharge, but not a cutting spark. I am glad to know that Mr. Stanley says that the so-called multiphase motors possess no advantage over the two-phase type devised by Mr. Tesla."

Mr. Stanley added that he did not believe there was any possible benefit to be derived from using a multiphase motor system, as he claimed that not more than two currents of ninety degrees of phase were required to produce a perfectly rotating field (meaning, doubtless, a rotating field which did not pulsate). He thought that Mr. Tesla, in the wonderful work that he did early on that subject, outlined the exact conditions of the operation of his motor.

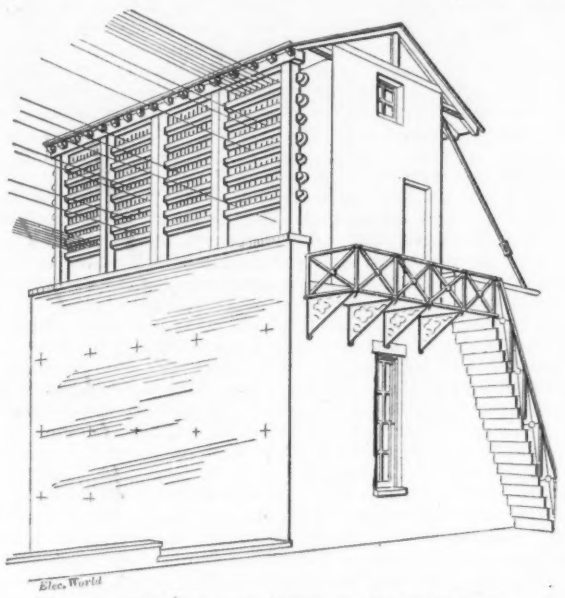


FIG. 1.—PERSPECTIVE VIEW OF WIRE TOWER.

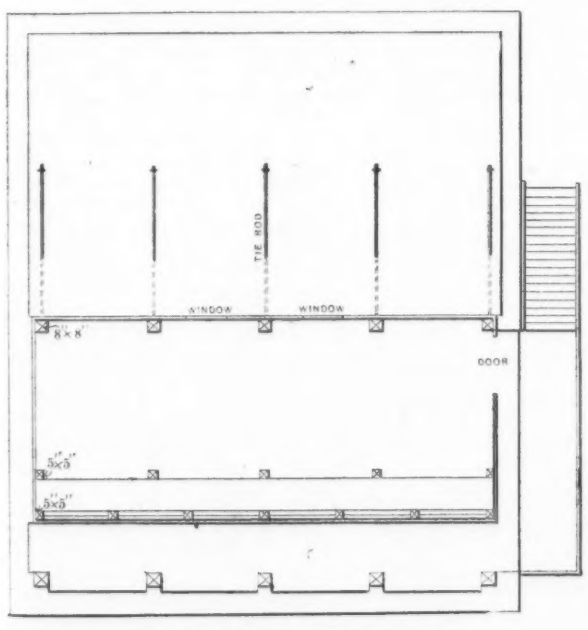


FIG. 2.—PLAN OF WIRE TOWER.

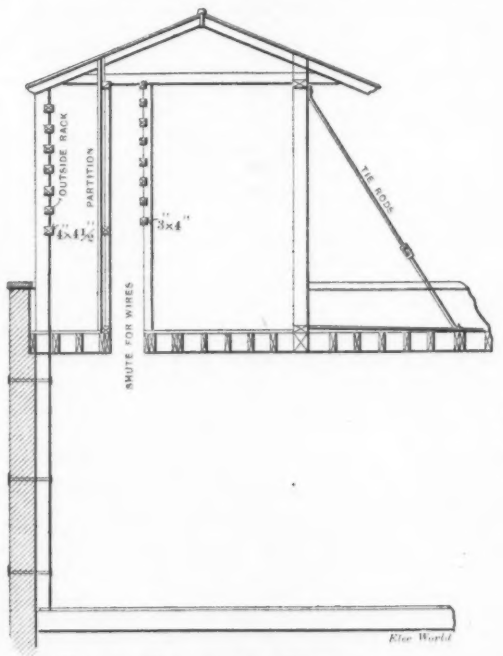


FIG. 3.—TRANSVERSE SECTION.

Overhead Construction.

BY E. F. PECK.

In view of the great interest taken at present in underground construction, it would seem almost incongruous to agitate the well worn subject of overhead construction. Still, as the majority of electric lighting companies in this country will have to contend with this method of construction for some years to come, it may be that the subject will still be debatable. There is certainly room for improvement in this direction in many of our cities and towns, due, perhaps, to the fact that it has been the practice of electric lighting companies to cheapen as much as possible this important branch of their work. Then, the material which has been supplied in the past has not been of such character as to permit first-class work; and, rather than stand the expense and loss of time incidental to the manufacture of special fixtures, a great many companies have used fittings that were originally intended for the much lighter work of telegraph and telephone companies. The work was also done with a view to the present only; and the rapid increase of business has overtaxed the poles and fixtures, which had originally sufficient carrying capacity. It may readily be seen that this has led to the erection of overhead lines that have, after a year or two of service, become dilapidated, unsightly and dangerous. Then patching was in order, which soon resulted in a tangle and snarl that grated upon the nerves and tried the patience of the central station manager or superintendent, whenever he had to contend with it. This, briefly speaking, has been the history of the company with which I am connected, and is, no doubt, the history of many of the companies represented at this Convention.

How can this state of affairs be remedied? In order to answer this question as briefly as possible, and, at the same time, to bring out a discussion that will, I trust, prove both interesting and instructive, I will outline some recent work that has been done under my supervision in Brooklyn.

We have reached that point where further patching was out of the question and reconstruction became a necessity. The first point of attack was our switchboard. This was the old style plug, socket and cable board, with wooden framework, originally designed for 36 circuits and 36 dynamos, but now, due to the increase of our business, handling 53 circuits and 42 dynamos. I will not dwell long on this subject, as I understand that an exhaustive treatise on switchboards has been prepared by one of our members. The switchboard that I have planned is arranged to manipulate 80 circuits and 66 dynamos, divided into three units, which I will describe as sections *A*, *B* and *C*—circuits and dynamos in each section being interchangeable—section *A* to provide for 32 circuits and 22 dynamos, and section *B* and *C* each providing for 24 circuits and 22 dynamos. Each section consists of two rectangular slate slabs placed five inches apart, supported on a suitable framework of steel I beams and channel bars, occupying three sides of a square. Into these slabs are fitted rows of metal bushings, which are properly connected together by copper strips, so that the horizontal rows of bushings on the front board are connected to the dynamos *via* single throw jack knife safety switches, while the vertical rows on rear board are connected to the circuits and also to an extra row of bushings on the bottom of front board. This extra row is used to connect two or more circuits together by means of cables and plugs, the connecting of dynamos to circuits being done by means of an ordinary plug of brass tubing, provided with an insulated handle. Above the switchboard proper, which stands about five feet high, slate slabs extend to the ceiling of the room in which the board is located, providing space for necessary lightning arresters, combined ammeters and polarity indicators for each circuit.

The next improvement which became necessary was the building of a suitable wire tower. The wire tower of a central station is an unknown quantity and a problem that is hard to solve. The first question is as to its shape. Shall it be rectangular, octangular or circular? This can only be answered by one having a thorough knowledge of the situation of the station and the directions which the circuits are to take after leaving the same.

While at Montreal I saw a very pretty arrangement of a wire tower on the new station of the Royal Electric Company. It was octangular in shape, each side being about 10 feet wide, with a rectangular section of slate framed into each section. This permitted the introduction and insulation of wires without other precautions, and, owing to the shape of the tower, provided for a lead for the circuits in eight directions. In our Brooklyn station, it was necessary to have the wires leave the tower in one direction only; so it was built rectangular in shape (see Figs. 1, 2 and 3). The tower is built directly over the switchboard and is 23 feet long and 10 feet wide. The framework of the tower, inside wire rack and outside wire rack, are all framed and bolted together, and guyed to the roof in the rear of the tower by means of wrought iron rods, provided with turn-buckles. The front, or side through which the wires enter, is made up of two thicknesses of two-inch plank laid diagonally to each other and fastened together with wooden pins. This was done to insure sufficient strength without framing and to permit the promiscuous boring for glass bushings. The inside finish of the tower is of hard oil varnish, and the outside of three coats of insulating and fireproof paint. The roof is of slate, the eaves of which extend over the outside rack, thus, to a certain extent, sheltering it from the weather. At the bottom of the inside rack of the tower is an auxiliary slate switchboard of very simple construction, consisting of two rows of metallic bushings and binding posts. By the use of plugs and cables on this board the tangles and cross connections, incidental to all central stations are confined to this particular point. This arrangement also permits the transferring of circuits to any one of the sections of the main switchboard, thus adding to the flexibility of the entire system. From the outside rack the wires are carried to a distributing pole (see Figs. 4, 5, 6 and 7) of Norway pine set directly opposite the centre of the tower. This pole is 92 ft. long, 30 in. in diameter at the butt, 18 in. in diameter at the top, and is set 12 feet in the ground to insure stability. This height was necessary to allow wires to clear a three-story building to be built in front of the wire tower. On this pole are fitted 11 double sets of eight-pin arms, and 11 double sets of 16-in. arms, a total of 44 arms, providing for 176 wires, or 88 circuits.

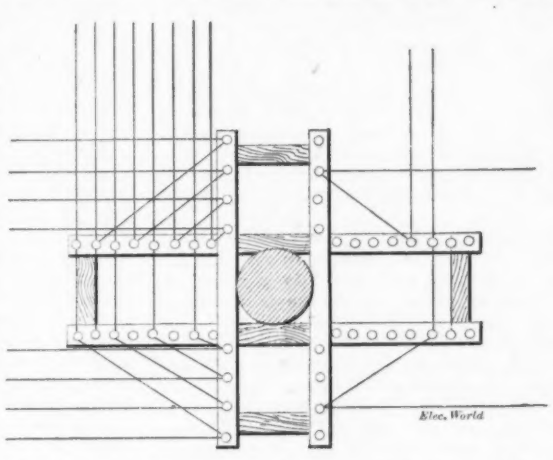


FIG. 5.—PLAN SHOWING ARRANGEMENT OF WIRES

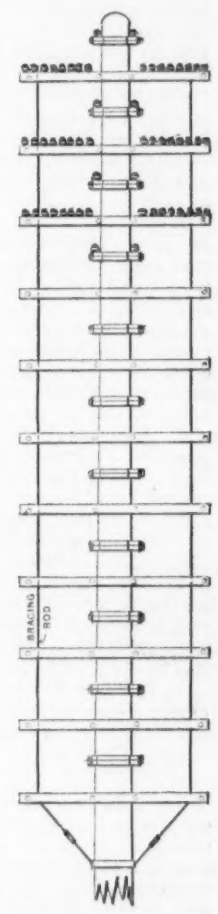


FIG. 4.—ELEVATION OF POLE.

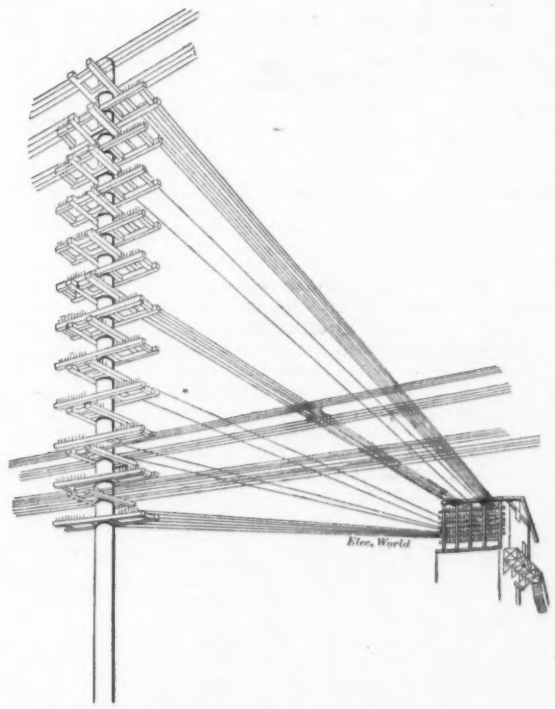


FIG. 7.—PERSPECTIVE OF POLE AND WIRE TOWER.

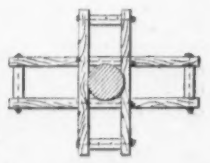


FIG. 6.—PLAN OF POLE SHOWING ARRANGEMENT OF WIRES.

SOME TYPES OF OVERHEAD CONSTRUCTION DESIGNED BY MR. E. F. PECK.

The 16-pin arms are set parallel to the arms on the tower rack, and the eight-pin arms are at right angles to same, to enable wires to run north and south. These arms are of the best quality of long grained oak of the following dimensions: Eight-pin arms are eight feet long, three and three-quarters inches by four and one-half inches, pins nine inches between centres—excepting pins nearest the middle of arm, which are three feet between centres, to allow a man to pass between wires when ascending the pole. Sixteen-pin arms are 10 feet six inches long, four inches by five inches, with pins six inches between centres. The pins used on these arms are of selected locust, one and one-half inches in diameter, and the glass insulators are of the deep grooved double petticoat pattern. The bracing and fastening of the arms can best be seen by referring to the sketch.

From this point the poles gradually decrease in length until a height of 50 feet is reached, which height is maintained on all our main lines. On lines carrying from eight to 16 wires octagonal chestnut poles are used, 35 feet long, 10 to 12 inches at butt and six to eight inches at the top. Lamp poles are of the same material and shape, 24 feet long, eight inches at butt and six inches at top.

Particular attention is paid to the guying of poles where necessary; and we are using for this purpose four No. 6 B. & S. galvanized iron wires twisted together to form one strand, and introducing turn-buckles on all main guys. This wire is purchased made up in this manner, and we find it a great improvement and saving over the old method in vogue, of allowing linemen to waste their time in making up guys as needed.

While on the subject of poles, I wish to call attention to what I consider an erroneous method of treating poles to preserve them

*A paper read before the Buffalo Meeting of the National Electric Light Association.

which is practiced by many companies. Pitch or tar is applied to the butt, thus confining the sap, which ferments and hastens decay. There are many different ways of treating poles, but I know of no method which is successful unless applied to the entire pole. The well known creosoting process is objectionable on account of the dirt and the unpleasant odor connected with it, as well as the fact that the creosote does not penetrate to a sufficient depth. The same objections apply to the Burnetizing and Kyanizing processes.

My attention has been recently called to the Haskins process, which seems to be highly successful. This process consists in the placing of timber in an air-tight retort and subjecting it to the heavy pressure of superheated air, which permeates the whole section, thereby accomplishing the same result as a charring process, without losing any of the chemical properties of the wood.

In regard to the character of wood to be used for poles, the choice is limited in the vicinity of New York, those obtainable being chestnut, Norway pine, princess pine, cedar, yellow pine, spruce and white pine. The princess and Norway pine, although not as durable as chestnut, are the most desirable for the heavier poles, on account of their straightness and size. For lighter work I prefer hewn or sawed chestnut poles to all others, and they are still obtainable in lengths up to 40 feet. Cedar poles are excellent as far as life is concerned, but too crooked and knotty to be useful for first-class work. My experience with yellow pine, spruce and white pine has been very discouraging, the life of each being short and uncertain.

The next step in the way of improvement which suggested itself was a better method of hanging commercial lamps. It has always been a source of surprise to me that more attention has not been paid by lighting companies to this important matter. The small additional expense necessary to ornament these fixtures certainly ought to warrant an improvement.

Last in the line of improvements came the wiring. It was only a question of rubber covered wires *versus* weather-proof. We compromised the matter by using the best grade of rubber covered wire for all leads from the switchboard to the main poles and on all lines crossing under telephone and telegraph or uninsulated wires. For the balance of the reconstruction the best grade of weather-proof wire was used. It will be noticed that I have used the term "best grade" for both classes of wire. This term is a little ambiguous, as I am reminded each day by our friend, the wire salesman, who claims that his brand of wire is the best, and that all other kinds are not in it. So it remains for the purchaser to judge for himself as to the respective merits of the different brands in the market.

On some of the loops to buildings, where two or more circuits were necessary, we have used, with great success, duplex cables, thus doing away with a complicated and unsightly network of wires and fixtures. All wires are run on deep groove double petticoat insulators, the use of rubber hooks and porcelain knobs being avoided. It would be difficult to formulate rules for this branch of construction, it being simply a question of judgment and experience. However, a few suggestions may not be amiss. Great care should be used in the stringing of wire, for the insulation of a whole circuit may be ruined by the carelessness of linemen in handling. Joints should be soldered on all electric light work when possible. I have found that wrapping a joint with tin foil, and then covering with a good rubber tape, makes an excellent substitute for soldering, and is easily applied. Keep wires on the same relative pins to the end of the line, thus avoiding confusion, and making it an easy task to locate trouble.

Diagrams of principal poles, showing location of circuits, should be kept in every central station, for they are often the means of preventing serious trouble. Do not leave loops up that are out of service, expecting to pick them up again, as they may become a menace to your live wires. If more attention were paid to overhead construction by the electric lighting companies, substantial, neatly painted poles being used, with well-insulated wires kept taut and thoroughly inspected, the everlasting hue and cry against the "deadly" electric light wires would soon change to one of commendation and praise.

Prof. Elihu Thomson, being called upon to open the discussion, said: "I have not given the subject of overhead construction much thought, but I agree with the sentiment expressed in the paper, that were it not for the fact of the unsightly ways of overhead construction we should hear less criticism from the public. If we had our wires well planned, if they were kept from an appearance of straggling and uncertainty of direction, I think the public would like and appreciate a good overhead construction as much as they might an underground. It is true that it would be desirable to get the poles out of the way; but an underground system means certain difficulties and large expenses which must be paid for by the user. I have always been of the opinion that a well-constructed overhead line—every detail studied as are other problems, every change of direction made with reference to permanence and sightliness—would do away with a vast amount of the objections which the methods in vogue have given rise to. The chief difficulty is that the lineman is instructed to go and string up as soon as he can to light somebody's premises; he has got the whole charge of the thing, and he is not always instructed in his business, and perhaps has had his training in the hanging of telephone wires, and we know they are stretched about in all ways; and when he takes up the heavier work of electric light wiring as an extension of his business, he adopts practically the same methods. I noticed during the reading of the paper that it recommended, instead of soldering joints, tinfoil may be used. That may possibly work for such circuits as arc light circuits, for the reason that although the tinfoil is not to be relied upon as making the connection, it would undoubtedly act as a kind of sealing agent to keep the elements of corrosion away from bright copper. If copper wires are brought together and wrapped over with tinfoil we practically get a sealed joint, and the brightness of contact may be preserved for a long time. We know that copper connections, when fairly bright—not rusted—will make practically a good connection. I think a great deal can be done in the way of the fittings of lamps in the streets. Abroad this matter has been, perhaps, better understood than here. Our desire in the past has been to get into business as soon as possible. It should now be our desire to get our business in as good trim as possible and make it as permanent and attractive as possible. Abroad the habit is to put up light ornamental poles for the arc lamp, and some of the designs are really elegant and not expensive. It is true that it might entail a considerable original investment, but if occasionally a wooden pole could be here and there replaced with a light iron pole, we should have a gradual evolution going on, and the result would be very satisfactory."

Mr. Seely: "I think there is only one way of making a joint, and that is twisting it with some kind of a sleeve. I have tried the tin-foil, and I find in using it the linemen are not careful with it. After it is put around the wire, in taping it, it is often abraded, which opens the seams of the foil. A soldered joint is preferable, I believe. Of course, it is sometimes a difficult matter to solder a joint in the street, but they manage it pretty well by carrying a small solder pot and blow pipe. We then cover the joint with a rubber liquid, something similar to what I understand Mr. Leslie and Mr. Brown have used in New York."

Mr. Peck replied: "In regard to using tinfoil on a joint, I did not mean to have it understood that I recommended its use. I simply spoke of it as one method of making a joint, when it was not easy to solder. We sometimes have orders come in at three o'clock in the afternoon and the party wants the light at five, and we are obliged to cut into our lines and make a quick job; and when it comes to taking a solder pot, and all that, we haven't time. I only intended to speak of it as one method, being a little better than a common joint with simple tape. The tinfoil will protect the joint from the effect of the rubber and is better than a plain joint."

Mr. Seeley thought it a mistake to erect large poles, claiming that it has been thoroughly demonstrated in the past year by the Long Distance Telephone Company that they are failures. An 80-foot pole is liable to break in heavy storms in winter, and surely we are carrying more weight with a copper wire on a pole than the small No. 12 wire used on telephone poles. The average pole, in his opinion, should not exceed 50 feet in height. He thought there was little use in protecting poles in the earth with any substance whatever, as it is an expensive luxury. Mr. Peck replied that he did not recommend high poles, but said that it was a point which each central station man must settle for himself. On their usual lines they use a pole from 35 to 50 feet.

Mr. W. D. Law described his method of locating grounds and open circuits as follows: "I use an arc light machine of independent power. If you have not an arc light machine of independent power, it would perhaps be well, if you have a large number of lines, to provide a small dynamo. In the location of grounds on all arc light circuits I use a bank of incandescent lamps in series, of the same voltage as arc light lamps—50 to 52 volt lamp is about the proper thing—using about five more lamps than you have arc lamp capacity for in your dynamos. These lamps are coupled in series, with the wire leading from each lamp to a circular switch, which may be moved to cut out 1, 2, 3, 10, 25 or 50 lamps, as the case may be. By connecting one side of this lamp bank to your circuit, say the positive side, and the other side to the ground, you will either have your lamps burning at full candle power or perhaps not showing anything. Then immediately turn these lamps on or turn off until they are brought to their proper potential or candle power. If you have, for instance, ten lamps burning on your positive side, then go on to the negative side and go through the same process. If you have sixty lamps burning on your circuit, and you have only ten lamps burning on the negative side your ground lies between these two points, you then have the location. I have invariably been able to settle the point within one or two lamps. This is a great advantage when you are in a hurry, and have a circuit of ten or fifteen miles, and generally start on the wrong end, as is the case nine times out of ten in the other methods. It is a good thing to have a horse and wagon for this purpose. We have a machine running at slow speed—a definite speed of about 300 revolutions, from which you will get a spark an inch and a half or two inches long, and still not sufficient, if a man gets caught, to do him injury."

To this suggestion Mr. J. E. Lockwood replied: "I think that is an unsafe method. I know of a case where it was fatal, and I do not think there is anything any company would want to introduce that would bring in any new element of danger. I believe the magneto bell answers the purpose fairly well. If it is done with a dynamo, the order should be imperative to the man in charge of starting the dynamos that the man sent out to locate the break is the only man to give the word to start. He can then feel reasonably safe and do his work all right. I do not think one station out of fifty would put in a small dynamo; they have not the facilities for running it. I think the safety of the men is of first importance."

In answer to this Mr. Law added: "I would say that my orders are imperative that this dynamo should not be run above a certain speed. The man who goes out on the trouble informs himself as to the manner in which the dynamo is running before he starts. I have handled this system for over ten years and have had innumerable open circuits, and have never had a man injured in any way. It is preferable, as I said before, to use a small dynamo. A magneto bell is not to be relied upon in a test of this kind. I was out the other day with a magneto bell. There were heavy grounds on the circuit, but there was force enough to ring the bell, and it was impossible to hunt up the open circuit. I never had that difficulty when I used the dynamo. If you are positive, and your orders are obeyed at the station, there is no danger of any man being injured."

Mr. E. A. Leslie then referred to the self-induction of overhead wires, particularly when not strung on the poles in such manner as to neutralize each other, and quoted a number of tests recently made on his lines in New York, showing that in the case where the proper arrangement of the wires on the poles has been neglected the apparent resistance of the circuit was 60 per cent. higher than in the case where this matter had received attention.

Mr. Stanley added that he had come to the conclusion that it would not be remunerative for us to put our wires underground until we found a system which would displace 20 wires above ground for one underground. This is about the ratio it works out at. With that means, in the case of an arc light circuit, you would put 20 times as many arc lights on one circuit, by some means unknown at present; and you would have to use at least five or six times the potential on the alternating circuit. Power stations would have to carry 20 times increased power before, in his judgment, underground service can be useful.

The Construction, Safety and Operation of Switchboards.*

BY M. C. SULLIVAN.

The switchboard is, or should be, the pilothouse of your station. Here should be located means for determining accurately the working of the entire system down to the minutest details. Disable your switchboard and, like wrecking the pilothouse on a man-of-war, you are helpless. The great advantage to be gained from centralization has been lost. It must, therefore, be apparent that every means should be exhausted to perfect and protect this apparatus

* A paper read at the Buffalo convention of the National Electric Light Association, Feb. 24, 1892.

In large composite stations, embracing arc and incandescent lighting, of both high and low tension, the power generators for street railways, condensation is one of the most vital features, not in the sense of crowding anything, but of utilizing every inch of space to install the apparatus necessary to do the work required. A most effective way to build a board for stations of this character is to have it arranged in the form of a square so that one side could be devoted to each division of the service.

Stations occupying a large open floor with high ceiling present the opportunity for building the ideal switchboard. This could be raised above the floor a sufficient distance, so as not to occupy any valuable floor space. For that matter it might be suspended from the ceiling. The wires from the dynamos could run directly to this loft, thence through the switchboard and from the latter to a cupola, arranged as nearly over the board as possible. This would give us a central starting point for our lines, enabling us to at once trace each and every wire in the system. However desirable such an arrangement as the above may be, the conditions are such that we cannot always do as our best judgment dictates, but rather have to make the best of things as we find them.

The prime object to be secured in switchboards for high tension service is safety, not only to attendants, but to the station. This safety can be secured by having every part of the board over which current is transmitted insulated in such a manner that contact from the front is impossible.

It is not necessary or advantageous to have the board arranged in the form of a perpendicular wall, as seems to be now the general rule. It is just as well to design it so that the switches can be arranged in the form of shelves up the front of the board, or, in the case of extremely large stations, the board itself could occupy the whole of the floor space in a room in some part of the station, and the instruments fixed on tables, leaving an alley way between the tables of sufficient room to get around readily. These tables need not be of any great length. They should be cut in sections so as to make the distance to be covered as short and direct as possible.

All switches and apparatus for whatever service should be manufactured with a lug or extension of the contact, so that the connection could be made from the back of the board. The resistance boxes and all of the regulating apparatus which require considerable space should be placed behind the board and provided with a rod extending through the face of the board. The board should be as symmetrical as possible, so that in rapid manipulations the grasping of a wrong switch cannot occur.

A very convenient form of board for arc light service is, to arrange two slabs of marbled slate, or other form of insulating material, leaving a distance of six inches between the two. One slab, say the inner one, may have connections from all the dynamos, each dynamo circuit having its own bar. The outer slab contains holes through which the current from these dynamo circuits may be plugged into any circuit or circuits, making a sort of a checker-board arrangement, the square being defined by the line wires running horizontally and the dynamo circuits running vertically or *vice versa*. The plugs by which the circuit is completed should have hexagon insulated handles so that a good hold can be had. All the lightning arresters, ammeters, etc., should be placed directly on the slate, or whatever may be used for the purpose.

We now come to the most important feature of the whole question, what material should be used for our switchboards? As it must be fireproof, the use of wood is prohibited. Various efforts have been made to make wood fireproof. This has been accomplished to a limited degree, but the element of doubt still remains. Slate, as many of you know, is the best thing which nature has yet offered us. For strength, lightness and insulation it is the *only* material in sight. Unfortunately, however, slate is an alluvial deposit of a limited character and often contains metallic substances which destroy its insulation, causing short circuits and other disagreeable features. When in the rough stone it is hydroscopic to a considerable extent and when it becomes saturated with moisture makes surface leakage possible. Great care should consequently be exercised in selecting slate for switchboards.

The drawbacks met with in slate have determined some manufacturers in using marble for this work. This has only one-fifth the breaking strain of slate, and where it is used instead of slate this must be taken into account. Marble presents the same hydroscopic elements of slate, and there is some metal in it, but owing to its peculiar formation this metallic substance is not in any great connected quantities as it is between the laminations in slate.

Iron should be used for the framework of all switchboards, and in the case of high tension circuits a wire should be run from this iron framework to ground, which is entirely insulated from the circuit, so as to prevent the board from becoming charged and discharged through a person who happened to be near by.

Complete plans and specifications for your board should be perfected, so that when an order is given to the manufacturer you will know whether it is his fault or your own if things do not turn out as you desire.

In the discussion which followed, some interesting points were brought out, showing varied and very widely differing opinions and experiences. Mr. Scott said in his station the switchboard was of wood, but he claimed it was fireproof, because it is wired in such a manner as to make it so. He furthermore stated: "I have found that the great danger from fire with switchboards is either from a dirty connection, a loose screw or from lightning. We have had trouble from all those causes; and in order to obviate the trouble from lightning we provided each feeder with a double lightning arrester. We have two lightning arresters on each leg of each feeder, running to separate grounds, so as to be certain that if one lightning arrester does not act the other will. In order that it shall not reach the main plug cut-out to the dynamo, we put a double fuse block cut-out on each feeder, and fuse that only to the limit of that feeder, fusing the dynamo cut-out to the limit of the dynamo; so that if any lightning does pass the lightning arrester and comes in, it blows the feeder cut-out instead of the main cut-out, from which it might arc and destroy the armature. I think that if managers will look carefully to these points—fuse their feeders less than they fuse their dynamos, provide as good lightning arresters as they possibly can, and have men thoroughly examine the screws and the connections at stated times—a wooden switchboard is just as good as a slate or a marble one. I do not believe in slatted wooden switchboards. I think a plain wall of well shellaced hard wood is better than slate.

"We have one of the wooden Westinghouse lightning arresters and one of the marble ones, on each feeder. We have had some terrific thunder storms that have come in and stopped the engine, but the arresters have carried them off."

Another switchboard of wood, and known as a Spencer plug switchboard, was described by Mr. Robinson, of Minneapolis. Regarding lightning he said that he also had some terrific lightning, and that he had seen lightning flashes come in that would destroy a switch and would not even flow the safety fuse; so that he had come to the conclusion that a fuse is not a protection against lightning; neither was a lightning arrester.

Mr. Leslie related some interesting experiences as follows: "We have suffered very severely from lightning in our station in New York. On one occasion there was a bolt of lightning came into the cupola and agitated all the lightning arresters, but at the same time burnt out our station. We then tried a slate board with rubber handles, and rubber all around it; that burned out one time when there was no lightning from arcing in throwing a heavy load from one machine to another. We finally devised one which we think answers the purpose and affords us absolute safety. It is made up of slabs of marbleized slate. The machine connections are run horizontally and are connected up by wires running from the machines overhead, the connection being made behind the board. The line wires do not come into the switch proper at all.

"On top there is a peculiar switch, termed a final switch, which is arranged so that it makes a connection on each side of the board. If you throw it up, the + terminal, for instance, will make connection on the face of the board, and the — terminal will make connection on the back. Both the line wires are connected with this switch, but they are securely insulated from each other, so that there is no possibility of short circuit there. The result is that we have a throw of about 18 inches, and no arc on any load that we have thrown there yet will follow it—although our lines are very long and the arcing is very severe. The board, made up in that way, is exceedingly simple, and there is no possible chance for a cross or contact between different exciters or different machines.

"We use the plug system. The board is arranged in two sections, so that if we are carrying our load on say nine or ten machines (we have 20 on the board) we set up the other section with the other machines, so that in case anything happens, just the moment that you throw over those switches you will start the whole load on the other machines. There is no studying out how to do this, that, or the other thing, but the board is always prepared for an emergency beforehand, and lies there in readiness for just the unexpected to occur. The whole success of the board is in that throw-over switch that I have mentioned—that final switch. It is quick, and we sometimes make changes in connection there that are very difficult to detect in their effect on the lamp itself, it is so sudden. The board itself is of slate and there is no wood to speak of about it at all. We do not believe in wood, because we have been burned out on account of wood. We had bad luck with lightning arresters, so we discarded them, and although we have passed through two summers of very heavy lightning storms we have not suffered any more damage to armatures than we did when we had lightning arresters."

One of the latest patterns of the Thomson-Houston slate switchboards was described by Mr. Fairbanks as follows: "The lines come into the back part of the board and the machines are connected in the front. Connections are made with a plug which reaches from one board to the other. There are in our board 20 circuits, so arranged that we can couple any line or any machine with any circuit. It avoids all cables, and it is perfectly safe. There is no place about the wood where a person could receive a shock in any way. In our station the switchboard is situated in the centre of the station instead of at the side. We can get all around it and test all our wires from the back of the board, or from the front. The wires come from each machine under the floor and come up on the under side. The line wires go out overhead, and before they go to the wire tower they go through the lightning arresters, which are situated right above the board in plain sight of the dynamo tenders, and where they can be easily reached. We like the board very much, and I have not seen anything elsewhere that is so entirely safe as that is."

The Relation of Size and Efficiency in Transformers.*

BY L. B. STILLWELL.

It is not intended in this paper to present an elaborate discussion of the relations of size and efficiency in transformers treated from a theoretical standpoint. If we were to select a certain type and, preserving for all sizes the same general proportions, agree upon a certain limiting temperature which all may be allowed to attain under working conditions, such a discussion would of itself be of interest, as pointing out the relations which exist between radiating surfaces and the amount of energy unavoidably lost in a transformer, but a thorough discussion upon such lines would involve a more or less elaborate comparison of the several factors which go to make up the sum of this loss, and for our purpose the possibilities of allowing greater loss in copper and less in iron, or greater in iron and less in copper, which are presented to the designer, are of less interest than a brief and necessarily general study of the effect of varying size upon the commercial efficiency of transformers as they are now offered by the manufacturer to the central station manager. Treatment upon these lines will also naturally call attention to other considerations of great practical importance, as regulation, insulation and weight. The variation in difference of potential at secondary terminals, when the transformer is without load and when it is loaded to its full rated capacity, should be a minimum; the insulation should be such as to practically prevent the possibility of electrical connection of primary and secondary coils, and the weight should not be so excessive as to cause serious inconvenience in handling.

The designer of a transformer has presented to him alternative paths. He may easily design with reference to a very small loss of energy and relatively high efficiency at light loads, if he is willing to sacrifice regulation. He may design a transformer of little weight and large output, if he is content to work at a very high temperature, which may perhaps endanger the lasting qualities of his insulation. The best transformer is not necessarily that which has the lowest leakage or magnetizing current; nor that which regulates most closely; nor that which is lightest and most easily handled; nor yet that which will carry its full load indefinitely with the least increase of temperature, but it is that transformer which best combines as much of each of these desirable properties as is practicable. In comparing various types, therefore, it is necessary to begin with a realizing sense of the fact that the same laws govern all types as to design and performance, and that, under the general laws of physics which have to do with this class of work, extraordinary excellence in one respect is necessarily obtained at the price of sacrificing excellence with respect to other properties equally important.

A glance at the files of the technical journals, or an examination of the records of the Patent Office for the past five years, will show that a very large number of transformers alleged to embody certain new and useful improvements have been suggested; or, as their respective sponsors would say, invented. Fortunately we are not called upon to discuss all of these. Five years in the development of electrical apparatus is a long time, and, while it may not yet be said of transformers in commercial use that only the fittest survive, it is noteworthy, as it is for our purpose fortunate, that there is a general similarity of type prevalent in America, and the more general relations of size and efficiency obtaining in a line of transformers, as furnished by one manufacturer, obtain in all. I propose, therefore, without venturing further upon the domain of theory than is absolutely necessary, to glance at what may be called the geometrical relations of transformers of various sizes, and so invite the attention of owners and operators of central station plants to a subject of very considerable practical importance to them.

Let us take, as a starting point, a very small transformer; for example, one of five lights capacity, the primary terminals of which are connected to an alternating current circuit of 1,000 volts potential. We will suppose that the lamps which are connected to the secondary circuit are all turned off. Under these conditions a small current, called magnetizing current, or leakage, flows in the primary coil. This current magnetizes the iron and, as a result, we have in the primary what is called a counter E. M. F. Every transformer, small as well as large, which is connected to this dynamo circuit, must develop a counter E. M. F. approximately equal to that delivered to it from the dynamo. This counter E. M. F. depends upon the alternating magnetization of a certain amount of iron, and the magnetization of this iron means the expenditure of energy. The amount of iron required and the expenditure of energy necessary will naturally be less in a transformer of small capacity than in one of large capacity, but there must be some iron magnetized, and some energy expended in holding back the E. M. F. of the dynamo. It is safe to say that a commercial transformer, by which I mean a transformer that can be manufactured at a cost that will make it a commercial or salable article, cannot be so designed as to have a loss of less than 20 watts, due to the magnetization of the iron. A transformer twice as large—that is, of 10-lights capacity—is called upon to do precisely the same work and no more, is developing counter E. M. F. to oppose that of the dynamo, and may quite as easily be designed to work with an iron loss of 25 watts. If the rated capacity of the five-light transformer is 250 watts and of the 10-light transformer 500 watts, the loss in the former will be eight per cent and in the latter five per cent. A 20-light transformer may as easily be designed to work with an iron loss of 30 watts, and a 40-light transformer with an iron loss of 45 watts; the percentage of loss in these cases being, respectively, three per cent. and 2.25 per cent.

One 10-light substituted for two five-light transformers will reduce the amount of energy lost in magnetizing the iron from 8 to 5 per cent.; a saving of 3 per cent. One 40-light substituted for two 20-light transformers will reduce iron loss from 3 per cent. to 2.5 per cent., a saving of one-half of one per cent. About the same percentage of saving can be effected by again doubling the size, and 100 light transformers can be furnished in which the iron loss does not exceed 1.7 per cent. Beyond this figure it is easily seen that improvement is difficult, and even were it possible, by employing a very large transformer, say, one of 500-lights capacity, to reduce iron loss to 1 per cent., the improving in efficiency resulting from the substitution of one of this size for five of the 100-light size would be but a fraction of 1 per cent., and, in view of the necessarily greater weight and the obvious objections to putting a large number of eggs in one basket, the advisability of such substitution would be doubtful.

Thus far we have considered only the loss in iron when no current flows in the secondary circuit, and it will be sufficiently accurate for our purpose to assume that this iron loss remains constant under varying loads of the transformer. The loss of energy due to the resistance of the copper when no current flows in the secondary is negligible, since the magnetizing current in the primary is very small, but this loss increases as the load on the transformer is increased, and the increase varies as the square of the current flowing; that is to say, the copper loss is four times as great when two ampères flow in the secondary circuit as when one ampère flows in that circuit. In the transformer without load we have a certain loss of energy designated iron loss, while in the transformer fully loaded we have this same iron loss plus the maximum copper loss. For intermediate loads we have approximately the same iron loss with varying copper losses dependent upon the amount of the load.

The loss due to the resistance of copper is generally about two per cent. This does not vary materially with a variation in size of the transformer, certain considerations having to do with regulation being largely accountable for this fact. If we assume that the loss in copper at full load for every size is two per cent., and that the iron loss is constant, irrespective of the load, the following table will, with sufficient accuracy, indicate iron and copper losses and efficiencies at full load. The table does not represent actual measurements of selected transformers, but is intended to fairly represent the proportionality of losses in transformers of various sizes. Actual tests will show results as good as or even better than the figures given in the table.

Capacity in 16 c. p. lamps.	Loss in iron.	Loss in copper.	Efficiency at full load.
5	8 per cent.	2 per cent.	90 per cent.
10	5 per cent.	2 per cent.	93 per cent.
20	3 per cent.	2 per cent.	95 per cent.
30	2.5 per cent.	2 per cent.	95.5 per cent.
40	2.3 per cent.	2 per cent.	95.7 per cent.
60	2.1 per cent.	2 per cent.	95 9 per cent.
80	1.9 per cent.	2 per cent.	96.1 per cent.
100	1.7 per cent.	2 per cent.	96.3 per cent.
300	1.5 per cent.	2 per cent,	96.5 per cent.

It will be seen that for sizes of less than 20 lights capacity the falling off in efficiency as we go down the scale of sizes is very rapid, while, on the other hand, the gain in efficiency of transformers larger than that of 20 lights capacity is much less marked. The exact significance of the table will, perhaps, be better shown by putting it in another form. Let us compare the losses at no load and at full load in 1,200 lights capacity of converters of each of the several sizes, and let us express the loss in each case in terms of the number of 16 c. p. lamps which the energy so lost would be sufficient to supply. We then have the following:

Transformers used.		Loss at no load.	Loss at full load.
240	5 light capacity.	96 lamps.	120 lamps.
120	10 "	60 "	80 "
60	20 "	36 "	60 "
40	30 "	30 "	54 "
30	40 "	27 6/10 "	51 6/10 "
20	60 "	25 2/10 "	49 2/10 "
15	80 "	22 8/10 "	46 8/10 "
12	100 "	20 4/10 "	44 4/10 "
4	300 "	18 "	42 "

These figures plainly show that to supply any number of lamps up to 100 it is desirable, on the score of efficiency, to use a single transformer of the required size rather than two or more of less capacity.

For sizes of a capacity above 100 lights the improvement in efficiency is necessarily little, and although the argument on the score of efficiency is still in favor of the use of the large sizes, that argument is by no means as strong as it was before we passed the 100-light limit.

This properly finishes the discussion on the relation of size and efficiency in transformers as they are to be purchased in the market to-day, but there are certain other considerations very closely connected with the subject which will naturally influence a central station manager. I have left myself no space for a discussion of these points, but they are, for the most part, of a very obvious character, and it will be sufficient to simply mention them.

In favor of the use of large sizes is the very practical argument of reduced cost per lamp capacity. In giving proper weight to this consideration the purchaser should assure himself that the manufacturer has not effected a reduction in cost at the price of an excessively high limiting temperature, which may endanger the lasting qualities of the insulation.

Transformers of 300 or 500 lights capacity are naturally large and difficult to handle; or if they are not very large it will be well to again note the temperature.

An investment in a 500-light transformer is large as compared with an investment in one of 100 lights capacity, and the chances of accident, such as may be caused by lightning, are quite as great in the case of the former as in the case of the latter.

It is extremely improbable that a static discharge from the line caused by lightning will damage more than one of a group of five transformers which may be connected together in multiple arc, while a discharge which may break down the insulation of one of these will be quite as likely to damage a 500-light transformer.

In the discussion which followed, Mr. Wm. Stanley, Jr., differed with the author regarding a non-heating transformer, and stated that in his opinion the most efficient transformer that could be made would be the hottest transformer. "The problem of building a transformer is to build a coil of wire and get as much iron in it as you can; that is, to surround a given amount of iron with as many turns of wire as you can; or, to surround a given size or coil of wire with as much iron as you can." He thought that the table given of the efficiency of the various sizes was very good. Regarding his own recent work he said: "We have had occasion lately to design transformers of very high voltage, as high as fifteen thousand volts, and we are now designing some to deliver forty thousand watts, or 50 h. p., each. We find no difficulty in keeping the temperature of these transformers within reasonable limits. They will get hotter than a small transformer. It is better that they should; but I do not believe any well insulated transformer is in danger of breaking down. It depends on the kind of insulation. If you put in mica or paper, or any stratifying insulation, and subject it to a high potential, it will most certainly break down with that potential, by either a dynamic current or a static charge or a stroke of lightning; but if you fit it with a homogeneous insulation, such as oil or some solid insulating compound, you can use any potential you want, provided the discharges do not take place that occur in stratified insulation. I think the heat has very little to do with the breaking down of a properly insulated transformer."

Prof. Elihu Thomson, praising the paper, said:

"It states facts, and facts which I have reason to believe are not far from the facts of truth. I do not exactly agree with Mr. Stanley in the statement that a transformer is better when it is hot. I would rather modify that statement in this way, that a transformer would run best if the iron would run hot and the copper as cool as possible; that is, the hysteresis losses of the iron would be diminished by the heat, and the resistance losses in the copper would be lessened by keeping it cool. If we could insulate the core of the transformer so as to prevent the escape of heat, and let it get hot, and keep the copper cool as possible by ventilating it thoroughly, we would then have the ideal transformer. I hardly agree with the statement that Mr. Stanley made that the insulation would not be injured by being hot. It is our experience that you cannot have a machine, a dynamo, or any other electric apparatus, run too cool, as regards the preservation of its insulation, provided it does not run so cool as to condense moisture from the atmosphere. The absolute resistance, the dielectric resistance, is highest when the substance is cool; that is, the tendency to puncture insulation is much less if you can keep your insulation cool. If you allow the insulation to heat up, its power of resisting puncture certainly decreases. The matter may be briefly stated in this way: if you take a good conductor like copper and run the temperature down, its resistance almost disappears at very low temperatures. Hundreds of degrees below zero, copper is almost a perfect conductor. If you heat it up it becomes more and more resisting. Let us take glass—a good insulator—or any insulating material, and run its temperature up, it loses its insulating power, and if we run it up until it gets to a red heat it approaches a conductor. All substances are conductors when they are hot enough."

Mr. Stanley replied that he did not mean to imply that it would not injure the insulation of a transformer to have it hot. "What I did mean to say is, that so far as the efficiency of the apparatus went, it would rather, on the whole, be improved by heating it. Of course, we can heat a transformer up so high that it will get on fire; but there ought not to be anything to burn. I question if the transformer of the future will have cotton or any other inflammable material in it. We are making transformers in which, if the coil is cut in two, the copper wires will be found imbedded in a solid dielectric, and the section would resemble the section of a well constructed cable. There is nothing to burn there. A temperature change of 30 or 40 degrees would hardly affect the dielectric strength, while it would materially affect the efficiency of the apparatus.

Mr. Stillwell closed by saying: "Prof. Thomson has fully covered the points of Mr. Stanley's first remark, to which I applied the same criticism as the Professor. With regard to the possibility of making a transformer, using for insulation only such substances as are not affected by heat, while that may be a theoretical possibility, I do not think that any transformer is now offered in the market which will be found to embody that kind of insulation. If you use only mica or something of the kind which is not affected by heat materially, then, in general, I should agree with Mr. Stanley that it is well for the efficiency to let the transformer run at high temperature. As it is, however nearly ever transformer, so far as I have examined them, does use insulating tape, or an insulating substance resembling tape, in one form or another. It may not be necessary, perhaps, to be guided to any extent by foreign practice in these matters; but in so far as the foreign practice is found to be in line with correct theory, I think it is of some use to us; and it is very noticeable, in the specifications of foreign engineers, that they limit, both in machines and in transformers, to a comparatively low temperature. Anything that is done in the direction of reducing the temperature, either in generators or in transformers,

* Read before the Buffalo Convention of the National Electric Light Association, Feb. 23, 1892.

by the manufacturing companies, is a direct gain to the purchaser; because I do not think it will be disputed that, taking the apparatus as it is built, such a policy tends to prolong the life of the apparatus."

Transmission of Power with Special Reference to the Frankfort Plan.*

BY CARL HERING.

With a Discussion by Prof. Elihu Thomson and Others.

A year or two ago the subject of electric railways was the most prominent branch in the later developments in the field of electrical engineering, and the almost phenomenal growth of this branch is known to all who have given the subject any attention. Just as that was the leading subject during the past year, so the subject of the transmission of power in large quantities over great distances seems likely to be the chief field of development in the near future, a bold beginning having been made during the past year in the form of a very successful public experiment made at Frankfort, in Germany, on a scale far beyond anything before attempted. I am informed that much attention has been given by the promoters of the Niagara Falls power plant to this experiment at Frankfort, and its success will doubtless lead to the adoption of the same or a somewhat similar system for the Niagara-Buffalo transmission.

In order to appreciate more readily that the advantages of electrical transmission over other methods are well founded and are not mere vague claims made by its advocates, let us review briefly the other methods, all of which have been in use much longer than the electrical one and have had a chance to show their limitations. Most of these are almost without a rival in their own narrow fields, but when it comes to transmission over long distances, the electric method stands almost alone.

The most prominent method of transmitting power is by means of shafts and belts, but although this is one of the best for very short distances, it need not be considered at all for anything over a couple of hundred feet at the most. In an electric light station in Rochester there is a belt 175 feet long and a shaft 200 feet long, and there are doubtless a few other exceptional cases like it, but it requires peculiar circumstances to make this practicable for even such a limited distance. Even for the short distances in workshops, shafts and belts have already been, and are rapidly being replaced, in many factories by individual motors placed in the immediate vicinity of where the power is required, and having their power transmitted to them electrically, which shows that even for such short distances electrical transmission encroaches on the field heretofore occupied entirely by the shaft and belt transmission. The only modification of the shaft and belt system adapted for longer distances is by wire rope transmission. This is an old, well exploited system, and its narrow limits are already well known. The poor efficiency, the liability to stoppages, and the great increase of cost with distance, are very much against it for long distances. The fact that it takes a two-inch rope, running at a speed of 2,000 feet per minute, to transmit only 36 horse power, is sufficient to show the impracticability of this system for long distances or large powers. A significant fact is that in Switzerland, where this system is used perhaps more than anywhere else, it is already at present being rapidly replaced by electrical transmission. Another fact which is significant is, as I am informed, that rope transmission is not being considered at all by the promoters of the great Niagara Falls plant.

Transmission by water direct is limited to locations which are peculiarly favorable and is not general enough to be considered here. In Zurich there is a high pressure reservoir located on a neighboring mountain, the water from which is used for power purposes in the city. There are doubtless other similar cases, but they are all limited to peculiarly favorable locations, as well as to comparatively short distances. Even in Zurich they are now installing an electrical plant, from which power is to be distributed.

Transmission by steam is of more general application, but the expense of the piping, the attention it requires, and the loss in the condensation, all limit its practicability to within a comparatively small radius, probably well within the radius of a mile at the most. It is in successful use in the city of New York, but its introduction does not appear to be making very rapid progress.

Transmission by gas as a fuel is in successful operation for very long distances of over 100 miles, but it is limited to localities where natural gas is found and its supply is, I am told, very uncertain.

Transmission by compressed air is perhaps the chief rival of electrical transmission, with which it shares many advantages over all the others. It is at present used chiefly in mines, where it is still a very successful rival of electricity, but from present appearances it is likely that it will gradually be replaced by the latter method. In Paris there is a large central station for the distribution of compressed air, and it seems to be in successful operation. It does not appear, however, that the advantages over electrical transmission are so great that it will not soon be replaced by electricity. Its introduction is not making the rapid strides that the introduction of electrical transmission is already making. Its efficiency as compared with electricity will be shown very well at the Niagara Falls power plant, where, I understand, a compressed air system is to be introduced in competition with electricity. One of the disadvantages for power purposes is in the fact that when the compressed air expands in the engines it generates cold to such an extent as to seriously affect the working and the lubrication of the engine. It appears that fires must sometimes be built to heat the air before it can be used at all in the engines; the advantages over a boiler and a steam engine are thereby greatly reduced. From a paper of Professor Unwin it appears that the transmission of power by compressed air is practicable to a distance of at least 20 miles. It seems that 10,000 h. p. can be transmitted to a distance of 20 miles in a 30-inch main at 132.3 pounds per square inch pressure, with a loss of pressure of only 12%. The efficiency of such a plant is said to be 40 to 50%, if the air is used cold, and 59% to 73% if the air is reheated. Mr. Coleman Sellers, one of the Niagara Falls Company's advisory committee, states in a recent paper that experiments were tried by a Mr. Saunders, of New York, of heating the compressed air at the receiving end by combustion within the mains; the result, he states, leaves little to be desired, as the product of the combustion is added to the quantity of compressed air, while the heated air and gas also increases the efficiency.

A very good idea of the relative efficiencies of several of these systems may be obtained from the following table by Beringer, giving the efficiencies for different distances.

Efficiency in Per Cent.

Distance in miles.	Hydraulic.	Pneumatic.	Wire rope.
½	50	55	91
1	49	54	85
3	41	51	61
5	37	50	43
10	26	43	21
13	18	39	11

The most usual and extended method of transmitting power, if so it may be called, is that of transporting the coal itself from the mines to the manufacturing cities. Although this is the system which is by far the one used most extensively, the objections to it are such as to offer great inducements to other competing systems. Even in Philadelphia, which is not far from the coal regions, the price of a ton of coal is said to be doubled by the cost of its transportation from the mines to the boilers in the city. In engineering terms this means an efficiency of 50 per cent. in the transmission only. An electrical system with such a poor efficiency in the line would scarcely be considered for a moment, and yet, strange to say, we are still transporting most of our power on the railroads in the form of coal and utilizing it in small individual boilers and engines, the efficiency of which is so low that even an amateur electric motor builder would be ashamed of his motors if they did not give a better efficiency.

It will be seen, therefore, that with the exception of compressed air and the railroads, the field is quite clear from rivals for electrical transmission, and that most of the disadvantages attending other systems do not apply to electrical transmission. Even in the two excepted cases, there are many advantages in favor of electricity, and it is probably only a question of time when they too will be replaced by electricity. Perhaps the most serious objection to electrical transmission is that it is new, an objection which is often a much more serious one to overcome than many engineering difficulties. If capitalists were all engineers and were not hampered by prejudices against new departures merely because they are new, what enormous strides engineering would make.

Coming now to electrical transmission, let us see which of the various methods stand chance of success for long distances. To be successful at all for long distances requires, beyond question, the use of very high potentials, as otherwise the cost of the line will make it impracticable. If continuous currents are to be used, they must be generated directly by the dynamo at that high potential, as there is no means at present known for converting a low tension continuous current into one of high tension without the use of moving machinery; continuous currents would therefore require that very high tension currents be produced directly from a dynamo with a commutator. Long experience and frequent attempts have shown that it is not practicable to exceed five or six thousand volts at the very most on continuous current dynamos, and even then there are many objections. As this would be a comparatively low voltage for long distance transmission, continuous current systems stand very little chance of being used for more than comparatively short distances. Another disadvantage is that the motors also must be run at this high potential, unless the current be transformed by a motor dynamo, which is awkward and expensive, as it involves the use of moving machinery requiring attendance. The starting of a motor at such high potentials also introduces difficulties. A point in favor of continuous currents is in the fact that the line is not charged and discharged continuously.

The field is therefore left tolerably clear for alternating currents, who owe it to two features, one that the alternating current dynamos require no commutator, and the other that such currents may readily be converted from a low tension to high tension and the reverse with but a small loss of a few per cent. in each transformation. An alternating current dynamo for generating low potential currents is the simplest kind of a dynamo, and a transformer requiring no moving machinery is a very simple thing to take care of, if, indeed, it required any attention at all. Simplicity alone, therefore, is very much in favor of alternating currents.

The only serious objection to the use of simple alternating currents for the transmission of power is that they are not so suitable for running motors as direct currents are. There is a class of motors called synchronous motors, which are, as a rule, simple alternating current dynamos used as motors, like in the case of direct currents. These must be run at a speed which must synchronize with that of the dynamo as precisely as if coupled to the shaft of the dynamo. They run very well after they are started, but many of them come to a dead stop if overloaded sufficiently to retard their speed below that of a synchronism, even if retarded only to a slight amount. Their chief fault, however, is that they cannot be started readily; furthermore all the load must be taken off before they can be started at all. Various methods are used to start them, but although they accomplish the object they can hardly be termed satisfactory solutions of the problem, at least as far as they have come to my notice. This makes them unfit for many purposes, as elevators, street cars, shops, etc. When there is only one large dynamo, which is started, say only twice a day, it can be done by a small inefficient motor or by starting both the generator and motor together, or by some other similar means, but when it concerns the distribution of power as distinguished from mere transmission, this disadvantage becomes of great importance. But this objection may not continue to exist very long, because with the amount of attention given this subject at present, it is not unlikely that some solution will be found before long, if it has not been found already. Several methods have already been devised for overcoming it, one of which was shown in the Frankfort transmission. Others are being at present worked out, among which may be mentioned that of Mr. Stanley and others; also that of Leblanc, which, I understand, is being experimented with on a large scale in the interests of the Rothschilds, of Paris. It is therefore likely that before very long this problem also will be solved by several methods so as to leave very few objections to the use of alternating currents.

One of the prominent features of the Frankfort transmission was that this motor problem was solved, as motors were there run, not only with the same ease with which continuous current motors are run, but with additional advantages which make them far preferable even to the best continuous current motors. The only objection to this system was that three wires had to be used in place of two, an objection which appears to be in many respects small as compared with the advantages gained.

There are in general two methods for transmitting to great distances by alternating currents. One is to generate the high tension currents directly at the dynamo; this is the system used at the Ferranti station in Deptford, London. At the distant end these currents are then transformed to low tension currents suitable for distribution to consumers. The second system is, to generate low tension currents at the dynamo, then to transform these at the dynamo station into high tension currents by means of transformers, which high tension currents are then sent through the line to the distant station, where they are transformed a second time back to low tension currents; this is the method which was used at Frankfort. The advantages of the former is that there is only one transformation, but a disadvantage which appears to outweigh the objection to an additional transformation is that the high tension current must be generated on moving machinery and that it must be controlled by switches and other apparatus, which must be handled by the attendants. The dynamos and switches are thereby rendered very much more complicated, and, as they must be handled, there is a constant source of danger to the workmen. This source of danger and the complications are overcome almost entirely by the second system. In the one used at Frankfort the dynamo was the ideal of simplicity in its construction, and the high tension circuit contained, with one exception, no switches or any apparatus whatsoever that required to be handled.

To recapitulate, it appears probable that the solution of the problem of long distance transmission will be solved by the use of high tension alternating currents originally generated at a low voltage, then formed into a high voltage, then sent over the line and finally transformed back to a low tension; this will furthermore be done by some system which will enable motors to be used on the circuit. The system exhibited at Frankfort was such a one and it appears to have been a perfect success in every way. It seems therefore that the problem has not only been solved, but also demonstrated by a practical illustration on quite a large scale.

Among the transmission of power plants in this country may be mentioned the following: One at the Dalmatia mine in California, in which the power is about 100 h. p. transmitted about one and one-half miles at 1,800 volts by direct current. Another in Virginia City, Nev., in which about 500 h. p. is transmitted a distance of about one-third of a mile, with an efficiency of 70 per cent. Another at the Calumet & Hecla mines, in which 400 h. p. is transmitted about one and one-half miles at about 1,000 volts, and at an efficiency of 73 per cent. These are all direct current systems (Brush). Another was installed by the Westinghouse company at Telluride, Colo., in which about 120 h. p. are transmitted two and three-quarter miles at 3,000 volts, and at a commercial efficiency of 75 per cent. This is of special interest, because it is an alternating current plant, in which the motor and dynamo must run synchronously. The difficulty of starting the motor is overcome by the aid of a small motor of 10 h. p., which is first run to bring the large one up to speed, after which it will remain in synchronism with the generator. The cost of this plant, exclusive of erection and line, is said to have been $10,000, or about $100 per horse power delivered.

A fair idea of the cost of transmission of power plants may be obtained from the following table of figures given by the Oerlikon company, and taken from plants actually installed by them, mostly in and about Switzerland. The table was copied from a paper read by Mr Saunders Morris at the Engineers' Club of Philadelphia.

Distance in miles.	H. P. delivered.	Cost in dollars. Generators.	Motors.	Line.	Total.*	Per H. P. delivered.
6.25	11	647	540	2,350	4,700	42.60
.43	510	.....	.....	.....	33,250	65.30
3.75	220	5,190	4,700	3,135	14,500	66.20
1.56	150	3,720	3,525	1,615	10,020	67.20
.56	71	2,155	1,960	294	5,100	71.60
1.87	85	3,135	2,741	2,155	9,220	108.50
2.20	51	1,761	1,567	1,469	5,595	109.40
5.00	41	1,174	980	1,682	5,000	121.10

* This includes regulating apparatus, instruments, poles, insulators, lightning arresters, erection and supervision.

The Lauffen-Frankfort plant has already been described in detail in my reports in THE ELECTRICAL WORLD; I will therefore give here only a brief mention of the chief features, referring those who desire further details to those published descriptions. For an opportunity to visit this plant I am indebted to this journal, in whose interests I went abroad during the past summer to make reports on this as well as other European plants.

This experimental plant was erected by the joint co-operation of the Allgemeine Elektricitaets Gesellschaft, of Berlin, and the Oerlikon Co., of Zurich, the chief engineering features being due to their respective engineers, Mr. Dobrowolsky and Mr. Brown.

The main object of this plant was two-fold, first to test and demonstrate to the public the feasibility of using very high tension alternating currents on bare overhead lines; secondly, to show the practicability of a modified alternating system especially adapted for running motors. The former feature was due to Mr. Brown and the latter to Mr. Dobrowolsky. It was an experiment in so far as it was at first not known whether such very high potential currents used on overhead lines would develop any new and grave difficulties, which were predicted by some mathematical electricians, involving capacity and induction effects. These fears were not realized, however, or in the terse language of Mr. Dobrowolsky, "the losses in the line all followed Ohm's law." The experiment demonstrated that with the use of carefully made and proportioned porcelain insulators containing oil, such high potentials can be used successfully on bare overhead lines. Strange as it may seem, one of the unexpected serious difficulties experienced on a line with similar insulators, was that such large white insulators formed tempting targets for the small boys to throw stones at, because a "good shot" from one of the little rascals was awarded by the pleasure of seeing the insulator flying to pieces, ringing like a bell.

The plant consisted in general of a dynamo of exceedingly simple construction generating a large current, but of only 50 volts. This was led through the switchboard with all its accessory apparatus and was then transformed by a step-up transformer into a small current of 16,000 volts. This was led through bare overhead wires a distance of 108 miles, where it was again transformed back to a low voltage by step-down transformers. It should be noticed that the currents at the dynamo and switchboard, where they had to be handled, were only 50-volt currents, thereby avoiding all possible danger to the attendant besides facilitating greatly the construction of the dynamo. In this feature it differed characteristically from the system used by Ferranti in London, in which the dynamo and switchboard were in the high potential circuit, the dynamo generating the high voltage directly. The Frankfort system was furthermore grounded in such a way that even in the case of a cross with the high tension circuit the voltage at the dynamo or switchboard can never exceed 50 volts above the ground. The second feature of this plant is, that it enables motors to be run with the same and even greater ease than continuous current motors. It therefore solved the problem of distribution as well as of transmission of power. It should be clearly understood that it was to solve the motor problem that a certain modified alternating current system, known as the three-phase system, was used. This system involves the use of three wires throughout in place of two, but it not only overcomes the difficulty of the distribution of power and the starting of motors, but it goes farther, because such motors are very much easier to run and are simpler in construction than the best continuous current motors, a feature which counterbalances to a great extent the objection to the use of three wires.

Time will not permit a detailed discussion of this three-phase system here, it will suffice to say that it consists of three simple alternating currents—one in each wire—the waves or impulses in the three wires following each other in succession similarly to the relative motions of the three cranks of a three-cylinder steam engine, or the pistons of a three-plunger pump. Such a set of currents produces a *rotating* magnetic field, while the simple alternating current produces merely an *oscillating* field. The rotating field furthermore has a definite direction of rotation. It is this feature of a rotating magnetic field as distinguished from an oscillating one, which renders it particularly well adapted to run motors. The ordinary simple alternating current motor may be said to be analogous to a steam engine with one crank, having its slide valve operated by an independent rapidly running engine; it has a dead point from which it will not start, but after it is up to

* A paper read before the Buffalo meeting of the National Electric Light Association, Feb. 23, 1892.

speed it will run very steadily. The rotating field motor, on the other hand, is analogous to a three-crank engine operating its own valves. There is no dead point, and it can start itself, even with full load.

As to the priority of invention of this rotary field system, I will only say here that Ferraris and Tesla seem to have invented it originally and independently of each other. Just in what respects Dobrowolsky improved it is hard to tell until we know how far Tesla developed it. It will suffice to say here, that as modified by Dobrowolsky, the motors appear to be an undeniable success.

In conclusion the following figures regardingthe Lauffen-Frankfort plant, together with a few illustrations of the details, may be of interest.

The small town of Lauffen is situated on the river Neckar, in the mountains, 108.6 miles south of Frankfort, and not far from the city of Heidelberg. There is a large water power there, 300 h. p. of which is to be transmitted electrically to the manufacturing town of Heilbron at 5,000 volts by this system. The turbine and dynamo of this plant were loaned for the Frankfort experiment. The turbine is horizontal, has a speed of 50 revolutions, and can develop 300 h. p. It drives a single dynamo by conical gears. The dynamo is of exceedingly simple and mechanical construction, has a speed of only 150 revolutions, and is capable of generating three alternating currents of 50 volts above their common connection, and about 1,400 ampères each, or a total of about 200 kilowatts. The number of alterations is 40, which is purposely made very low. This current passes through the switchboard and regulating apparatus to a three-coretr ansformer of equal capacity. The ratio being 160, it is transformed up to about 12.500 to 15,000 volts, measured between any two of the three wires, and down to four or five ampères; by connecting two of these with their primaries in multiple, and their secondaries in series, they will generate 25,000 to 30,000 volts.

An interesting feature about this system is that although the three currents have different phases, they need no separate return leads, because the nature of the currents is such that each acts as a return current for the other two in multiple arc. The three circuits are therefore merely connected together to a common terminal, after they have passed through the dynamos, transformers and lamps. This terminal, we will call the neutral point. This neutral point was grounded throughout the system, in the low tension as well as in the high tension circuits, and at both ends of the line. No current, however, will flow through the ground when the plant is working normally.

The line consists of three bare, hard drawn, copper wires, 4 millimetres in diameter (slightly less than a No. 6 B. & S. wire), having a resistance of about 2 ohms per mile. The distance being 108.6 miles, the resistance of each wire is about 217 ohms, which, with 5 ampères, makes a loss of about 1,000 volts on each of the three lines. The lines were run on poles with one cross arm 16 feet above the ground, the wires being one metre from one another. There were 3,227 poles, at 200 feet spans; each pole had a skull and crossbones painted on it to indicate the sure fate of any one who could not keep his hands off. There were 3,000 large porcelain insulators, 8 inches in diameter, made in two parts and with three oil grooves, and 6,500 small ones, made in one piece and with one oil groove. The only apparatus connected with the high tension circuit was the fuse wire and and a short-circuiting device to replace the switches for opening the circuit. The fuses for each of the three lines consisted of two copper wires in parallel, each .15 millimetre in diameter (between Nos. 34 and 35 B. & S. gauge) and 2 metres in length. They were stretched between two poles outside of the building. They were exploded (one can hardly apply the term "blown"), several times to test their effectiveness. Even to an electrician it seems strange to think of several hundred horse power being transmitted through a few wires about the size of a hair! The short-circuiting devices consisted of pieces of bare wire shaped like a V inverted, suspended directly over the line wires. These were placed at very frequent intervals along the line. In case of any danger or interruption, or in case the line must be handled, this wire is lowered by a string, and drops on the line wires, thereby short-circuiting the line, which blows the fuse and opens the circuit. This is a very cheap and effective substitute for a switch, which would be dangerous to handle in a 30,000-volt circuit; furthermore there is absolutely no possibility of a current being on the line when this device is down.

Both the high tension and low tension circuits were carefully grounded at both ends at the neutral point, that is, at the common junction of the three wires. This makes the system perfectly safe, for in no case can the voltage on the low tension circuit be greater than the normal low voltage. In case of a ground on the line, or a cross between the high and the low tension circuit, the fuses will blow.

Arriving at the receiving end, at the exhibition at Frankfort, the high tension current was transformed down to about 75 volts measured between any two of the three wires. Some of it was used to illuminate one thousand 16-c. p. lamps on the exhibition grounds, consuming 58,000 watts, and some was used to run a 100-h. p. motor, which drove a centrifugal pump, the water from which formed an attractive water fall on the exhibition grounds. The average voltage used on the line was about 16,000 volts, and the greatest amount of power, I am told, was about 180-h. p. This was not because of any failure to be able to transmit more, but merely because that was the full capacity of the bank of lamps and the motor.

The official tests are not yet completed, but from careful commercial measurements it was found that the efficiency from the dynamo current at Lauffen to the lamps at Frankfort was 72 per cent. when about 80 h. p. was transmitted, which is very satisfactory. It is furthermore probable that accurate measurements will increase rather than decrease this figure. It should be noticed that this was the efficiency for only 80 h. p. From this efficiency must be deducted the loss in the generator and that in the motor in order to get the total. After the Exhibition closed, the plant was also run at 30,000 volts; during that test one of the insulators failed. The plant was run in all kinds of weather without apparently any appreciable increase of the loss on the line. It was furthermore found that the predicted heavy losses, due to the condenser action, did not exist, and that for practical purposes these losses follow Ohm's law. It will be remembered that this was one of the uncertain features, the existence or non-existence of which this experiment was to prove. As the distance was far beyond that at which power will, in practice, be carried, say 30 or 60 miles, this experiment demonstrates that such a transmission is entirely feasible at distances met with in practice.

The Oerlikon company gives the following figures regarding the cost of the plant: Assuming that 300 h. p. is developed at Lauffen, and that all the energy received in Frankfort was converted into light, the cost of the plant per effective horse power, measured at the terminals of the lamp, will be about $282, of which $236 is for the line alone. These figure appear high, but it must not be forgotten that in this particular plant there were conditions which would not be likely to occur in practice—namely, relatively small power on the one hand and exceedingly great distances on the other, both of which factors naturally increase the cost per horse power.

It may be of interest to add here that Mr. Dobrowolsky, of the Berlin firm, states that he would be willing to bid on the contract to transmit 1,000 or 5,000 h. p. from Niagara to Chicago, a distance of about 500 miles. He proposes to use 40,000 to 50,000 volts and claims that an efficiency of 60 to 75 per cent. could be obtained without difficulty.

The paper was followed by a number of lantern slides showing the apparatus and the details of the plant, most of which were taken from the illustrations which have already appeared in these columns in connection with the detailed descriptions referred to above, written for THE ELECTRICAL WORLD.

At the close of his paper Mr. Hering read the following abstracts from a letter which he had just received from the Oerlikon company, of Zurich, Switzerland, who have made a bid for a plant for the transmission of power from Niagara Falls to Buffalo.

They propose that the system to be used should be such that not only motors, but also arc lamps as well as incandescent lamps, could be supplied by it. They claim that as the drehstrom (that is, the rotary current) is at present, and will be for a long time to come, the only practical form of current to run large motors of a fair efficiency, they have proposed the use of this drehstrom. They propose to use 50 periods in place of 40, which were used at Lauffen, because they say that 40 is too low for running arc lamps, 50 being the lowest at which arc lamps will run satisfactorily. The generating station would be composed of units (dynamo and turbines) of 5,000 h. p. each. The turbine designers have fixed the number of revolutions at 250 per minute. The diameter of the armatures has been fixed at 3½ meters, that is, about 10 ft. The armature is to be drum wound, that means, of course, that the drum winding is on the cylindrical surface of the armature and not across the ends, as we usually wind drum armatures here. The currents are to be 2,000 ampères in each of three circuits and the voltage 690 to 700. They claim that it is better to revolve the armature instead of the magnetic field, in order to have a minimum weight on the vertical turbine shafts, the weight on one of those shafts being already very great. The shafts are 120 feet long, and their weight, together with that of the armature and turbine, is very great, and must be taken into consideration. The generators are to have 24 poles, and will be separately excited. The efficiency will be in the neighborhood of 96 per cent., including exciting power. There will be two transformers to each dynamo, as it was not found practical to build a single transformer of 5,000 h. p. The transformers will be artificially ventilated, and only the high pressure coils will be placed in oil. The transformers will raise the potential to 25,000 volts, which they say, "is no longer to be looked upon as a venture." The cost of the whole line will be about 100,000 francs, that is, about $20,000, a small part of the whole. It is to consist, I presume, of simply three bare copper wires on poles; the cheapest kind of a line.

They propose to carry not more than one or two units of 5,000 h. p. on one line of poles, for a number of reasons. They state that 5,000 or 10,000 h. p. can be led on wooden poles at a very moderate initial cost of plant. The lines would terminate in one or more step-down transformer stations that would supply current of 1,800 to 2,000 volts for municipal and street lighting in the shape of alternating currents to be transformed down to the suitable lamp voltage, as is the case is the ordinary transformer system. The cost of the electrical part of the proposed plant, including the generators, exciters and transformers at both ends of the line (apparently not including the motors) would be about $180,000 for each unit of 5,000 h. p., with an efficiency of 81 per cent. at the low pressure terminals of the secondary transformers. This reduces to $36 per h. p., which is lower than the lowest one in the table in the above paper. The cost of the line reduces to about $4 per h. p., which is about 10 per cent. of the whole.

In the discussion which followed Prof. Elihu Thomson said:

I am sure the thanks of the association are due to Mr. Hering for the able paper which he has presented, and which covers a great many points. I have not very much to add, indeed, to the subject matter of the paper. He has had the opportunity of examining for himself the working of this grand experiment abroad, which has resulted apparently successfully. In the beginning of the paper he referred to various modes of transmission, and justly selected electrical transmission as the coming means of the transmission of power. We have in the case of the cable railway an example of wire rope transmission, and we all know—all those who have taken any pains to look into the matter at all—that there are very great losses in such a transmission unless it is confined within narrow limits. It is a common saying that very much the larger portion of the power in a cable system is used in pulling the cable around, and that the addition of the loaded cars to the cable makes only a moderate addition to the power required to move the cable. This is certainly true if we have a system in which there are a number of curves—the cable has to turn corners. I have no doubt the figures given by Mr. Hering relate to cases of cable transmission in which the transmission is practically straight, where there is an open country as it were, and the rope transmission can be carried across. If a good many curves or bends are to be made in the system of course the efficiency runs down very rapidly. But in reality with electrical transmission we may bend our wire as much as we please; we may turn as many corners as we please, and it simply adds a little to the length of the line, which can be made up by adding a slight amount to the copper used.

In referring to the compressed air system, which is used in Paris, he said: In that system it was found that the engines did not work efficiently unless the air was put through a heater, the reason being that when the air is compressed at the station it loses during compression a large amount of energy, which is converted into heat, and it has to be thrown away by cooling arrangements, cooling the compressing pumps. It then passes along the distributing points at the ordinary low temperature. The moment it reaches the engine and begins to be expanded in the engine it demands, to resume its normal condition, that the heat which is lost during compression be put back into it, and of course if it does not get that heat it simply chills—cools—and comes away from the engine very cold. The bad effect of this cooling of the air is, that is not only shrinks the air in volume and therefore relieves the pressure on the piston, on which you rely for the development of power, but it hurts the mechanical working of the engine; so that the practice in Paris is to put up a little stove and pass the water through a coil of pipe in this stove before it reaches the engine, and in that way they get a very fair efficiency out of the compressed air system; but it is only by the addition of this extraneous heat, and the consumption of extra fuel. It is true that the heat which is added to the compressed air as it enters the engine is very efficiently used. It is almost all converted into mechanical power. In fact if we had a supply of compressed fluid at our disposal at very high pressure, and then were to heat that and allow it to expand down to ordinary temperatures, we would have a very efficient way of using heat and converting it into mechanical power; but the pressure would have to be very high to make that a useful system.

Mr. Hering has also mentioned in his paper a form of transmission which is not ordinarily classed as transmission of power; that is, the carriage of coal from the coal regions down to a city where it is to be used. This is, as he states, in reality a transmission of power. That the efficiency of the conveyance now is no greater than 50 per cent. is probably due to some manipulation. It seems to me it ought to be higher. However, I do not know that I have investigated that subject sufficiently to pass a proper opinion. Whether the coal will ever be burnt in the mining regions and the power developed there, transmitted electrically, of course is a question to be considered. It depends upon the cost of carriage relatively to the cost of the conveyance of the electricity. If it should turn out that the plan of conducting the power electrically should give a lessened cost of carriage, the electrical plant must, it seems, take the place of the road in carrying coal, not perhaps for the development of heat. We are not likely to burn the coal at the mines and carry the electricity 50 to 100 miles, and then use the electricity for heat but for power. Heat is a different thing. We need to get a large fraction of the energy of the fuel in the case of heat, but for power we are at present content to get 10 per cent. or 12 per cent. in the steam engine, and use that.

It has been aptly stated in the paper that the commutator difficulty is the difficulty which stands in the way of the application of direct or continuous currents to power transmission. It is an actual fact that a commutator which is to stand indefinitely 3,000 volts is very expensive in construction. It requires very high insulation, very careful construction and very numerous segments. It has been found impracticable to raise the electrical pressure existing between two adjoining segments on the commutator beyond a certain amount. The current is apt to leap the gap between the segments and form short circuits. Therefore, for high voltages we need to divide the commutator up into very fine divisions. But that involves that the winding be also divided up. It makes it very difficult to wind the armature and connect it to such a commutator. The difficulties are undoubtedly great. I think the limitation would naturally be found somewhere between 2,000 and 3,000 volts for actual practical usage; that is, so far as the commutator is concerned; and if we attempt to transfer power at that potential and reduce it, we do not get rid of the commutator at any step of the process when we use direct or continuous currents. We are driven, then, as Mr. Hering says, to alternating currents; and he has shown in the paper that a very excellent example of power transmission by the alternating current is to use what is known as the three phase system with "double conversion," as it is called, and as explained in the paper.

The fact that transformers of large size can be built with very high efficiency—at a loss of only a very few per cent,—is of course in favor of the system. The fact also that there is no need of manipulation of the dangerous high potential currents is a great thing in favor of such a system. The only thing against it is the addition of apparatus and the necessity of taking great care of the insulation in a transformer. This difficulty, however, of insulation in the transformers seems to be overcome by immersing the transformer in a bath of insulating oil, when we find that it takes a very high potential to puncture even a moderately thin layer of oil. We find, for example, that one-half inch of oil will stand many thousands of volts—voltage beyond what we are likely to be called upon to use in practice—far beyond it. In other words, we can construct our apparatus with a considerable margin of safety by allowing the oil insulation to be thick enough.

I am greatly in favor of the three phase system. It seems to me that it is a symmetrical system, one allowing you to do almost anything you please with it. The only question in my mind is to whether you should take your lines over ground or underground. It is certain that if you went underground you would not require to paint on every pole a skull and crossbones. Currents of voltage up to 15,000 or 20,000 volts are, of course, certain death if a person comes in contact with them. We are approaching the condition of lightning—continuous lightning, not simply a stroke, but a continued stroke, a great number of strokes following each other in rapid succession. It seems to me, all things considered, although, perhaps it would be a little more costly to begin with, that for moderate distances the cost should not prohibit putting the lines in pipes filled with oil, that is, to use throughout the line the same insulation which is used on the transformers.

In other words, insulate the whole high tension part of it in oil, and bury the pipe. In that case you are practically free from any leakage due to wet insulators or interference due to lightning. It can be said, in favor of a high potential system, that the liability of damage by lightning is less the higher your potential; in other words, the nearer you approach lightning in the operation of your plant the less liability there will be that lightning will interfere with the operation of such a plant. It is constructed to stand a moderate phase of lightning, and it would take a considerable addition to break it down. Oil insulation, furthermore, regulates itself the moment it is punctured. Such a line might in a measure be struck by lightning and might be deranged for a moment, but the oil, passing in between, would end the difficulty. It is very different where the apparatus is not constructed to stand more than 3,000 or 4,000 volts instead of 20,000 or 30,000. There, if lightning comes onto the line and you are or are not provided with all safeguards, the question is whether damage is not going to result.

There are some other points about the three-phase system that I would like to bring out and emphasize. It seems to me that we can do a great many things with it. For example, we can get alternating currents at the receiving end for the running of lights direct from the mains, by conversion down to any voltage. We can therefore run any kind of apparatus which operates with single-phase alternating currents or with multiphase alternating currents. We have at our disposal, as Mr. Hering has shown, motors which can be run—and efficiently run—by the means of the three-phase currents directly fed to them without excitation of the field; that is, motors which do not synchronize, motors which do not run at quite the proper speed when loaded, but nearly the proper speed, very nearly; motors which run fairly well, and are adapted to distribution here and there. We can also run a machine from the same system of mains, which is a reversed alternating dynamo, and runs perfectly synchronized. If the generating plant runs at 130 to 150 turns, the motor may run at a defi-

nite speed depending upon the generator speed, that is, at that same speed or some definite relation to it, and it will stay at that speed, not varying a particle, being perfectly synchronous. In case, for example, we wish to lump all our power in the receiving station and run at absolutely steady speed, we might use the reversed dynamo, or the reversed three-phase dynamo, as a motor getting synchronizing speed. We can distribute by the other form, the non-synchronized form of motor, without any field excitation at all.

Suppose we desire to get continuous currents from three-phase currents—suppose, in other words, we have an existing plant which is based upon the use of continuous currents—it may be for street cars that are already equipped; or there may be mains laid in the streets which are adapted to use just certain pressures, and there may be motors running from those mains which are only adapted to use continuous currents; then we have resort to another kind of a machine, a machine which takes continuous three-phase currents and delivers from the other side continuous currents, which has no commutator on this end but simply three wires, and on the other end a low potential commutator, a commutator which gives you no difficulty in running 110, 220 or 500 volts. We may in such a case convert directly from the three-phase currents into a continuous current and supply the existing mains, and we may do that efficiently. We can, therefore, run from the same system a motor-generator, as it would be called, which is supplying 110, 220 or 500 volts, either with separate machines, or even in the same machine; furthermore, we can make such a machine so that it will compound itself. In case, for example, the machine is running with very little load, its potential will be, say, 220 volts; if the load is thrown on there will naturally be a fall of potential in the whole transmission from one end to the other, including that in the mains in the streets; this fall of potential can be made up by the construction of the machine; in other words, we can compound this motor generator by simply using the accessory field which Mr. Hering showed in the slide, and exciting that field by the secondary currents; that will raise the potential, and the system then becomes a completely compounded one.

Now, in closing my remarks I will simply state that you can imagine what such a system would do for New York City, for instance. There are now separate plants and stations in the city here and there on expensive ground and in expensive buildings. Supposing we go up the Hudson River somewhere and establish a power plant, get our coal very cheaply delivered, get water for condensing the steam in the engines, and get rid of ashes by making land somewhere. We then simply lay pipes down to the city, a distance of whatever number of miles is convenient, making the pressure what we find is proper for the economy in the transmission. We deliver current, three phase it may be, to the different stations, simply using motor generators feeding into the existing mains for the present systems. Should we wish to run out new mains with currents transformed down to low pressures, we can do it very easily. In other words, we could satisfy almost every need, even down to the plating current. We can give everybody what is required from such a system; at least that is how it strikes me.

Now, the question as to what pressure is the limit—what is the electrical pressure that would limit us in such transmissions as we are talking of—well, there really seems to be no particular limit. It would seem to me practicable, if it were necessary, to raise the pressure to 100,000 volts. It simply means that you have got to have your insulator oil thick enough not to be perforated by 100,000 volts. In some recent experiments I have made, I find that oil is excellently well adapted to stand such pressures; it is even better than solid glass. Where glass breaks down with perfect ease I find the oil stands up, or, if it does break down it reinsulates itself. If there is a puncture through the oil, and a spark flies, it does not necessarily involve the destruction of the plant, as the oil slips in and covers up the defect.

Mr. H. Ward Leonard was then called upon by the president to take part in the discussion, and responded by reading the following paper on "The Transmission of Electric Energy by Alternating Currents and its Utilization by Continuous Currents."

For more than ten years we have had at our command the means, through the agency of the continuous current, of transmitting electric energy in unlimited quantities over short distances and converting it into mechanical power for any desired application. The hundreds of three-wire systems illustrate this statement. For more than five years we have had at our command through the agency of the alternating current the means of transmitting electric energy in unlimited quantities over almost any desired distance, but we have not had the means of converting such energy into mechanical power for commercial uses, for there is but little commercial use for a motor which is not self starting and which when started can be operated at but one speed. Hence, the commercial use of the alternating current has thus far been confined to the operation of incandescent lamps.

During these past years the companies promoting the sale and use of continuous current apparatus have been making plans and estimates of continuous current transmissions using several thousands of volts directly from commutator to commutator; but neither they nor the public have had the necessary confidence in the result to install the plants. The developing and perfecting of a continuous current constant potential generator of 1,200 volts has forcibly impressed at least one company with the difficulties likely to be met with in constructing similar aparatus of 600 volts and upward.

At the same time the various companies promoting sale and use of alternating current apparatus have devoted all their efforts to the development of an alternating current motor which should possess the essential qualities of variable torque and variable speed under variable work. Thus far neither line of development has resulted in the production of commercial apparatus for the transmission of power over great distances. I believe that prejudice is largely the cause of this condition of affairs. Each side of the continuous vs. alternating current controversy has been bitter in its denunciations of the rival apparatus, and has apparently considered that it would be fatal to admit the necessity of using the rival apparatus to secure the result.

So long as incandescent lighting alone was under consideration it made but little difference. Either the continuous or alternating current would give satisfactory results. But not so with the transmission of power over great distances. The high tension alternating current says: "How easy it would be to get there if somebody could only utilize me." And the low tension continuous current says: "How easy it would be to use me for any application if somebody could only get me there." I stand here to make the claim that the transmission of power over great distances necessitates the use of both the alternating and continuous currents, and that by the combined use of the systems the result is commercial to-day over any reasonable distance and for the transmission of any amount of power. I arrive at this conclusion, as follows: The economical use of electrical energy with automatic control of the speed and torque demands that the voltage be varied as the speed and the current as the torque.

It will be evident that for merely transmitting electric energy from a prime motive power of constant speed there can be nothing simpler or better than the synchronous alternating current motor of constant potential. But nearly every application of the transmitted power demands not only a variable torque, but a variable speed, as will be evident when we consider hoists, locomotives, pumps and ventilating fans. The synchronous character of the alternating current is therefore unsuited for such work. We should have means of varying the voltage in proportion to the speed desired, and means of varying the current in proportion to the torque of the power to be supplied. We should also have a current adapted to charge storage batteries and to deposit metals electrolytically. All these conditions point directly and conclusively to the continuous current.

It would seem, therefore, that both theoretical and practical considerations demand that we should transmit our energy over the great distances demanded for commercial applications by means of the alternating current and that we should then convert our electric energy into a continuous current in order to best utilize it in the actual performance of the work met with in practice. Under this plan we shall be able to undertake the transmission of power at any distance and on any scale by apparatus manufactured by half-a dozen companies to-day.

Let us suppose, for example, that we have a water-power at a distance of twenty miles from a mine where it is desired to utilize 2,000 h. p. for various purpose. Let us start with 10,000 volts and lose 22 per cent in the conductor. The cost of our generator, conductor and synchronous motor will be about $90 per horse-power at the point of work. The synchronous motor will drive the necessary continous current generators of 500 volts and less to supply hoists, pumps, locomotives, ventilating fans, air compressors, incandescent lights, arc lights, crushers, mills, etc. If the total power installed be 2,000 h. p., the cost of the working motors will be perhaps $50,000. With 2,000 h. p. installed the maximun demand for power will not exceed 1,500 h. p. The cost of continuous current generators and conductors for this service will be about $52,500, and the cost of the synchronous transmision system about $135,000. Allowing $42,500 as an average cost for the development of the water-power and the construction, we have a total cost of plant of $280,000 or $140 per horse-power represented in the electric motors at the point of work.

The starting up of the synchronous alternating current motor without load can be readily accomplished by any one of several simple methods, such as the use of a small storage battery supplying currents to one of the continuous current dynamos and operating it as a motor to drive the alternator up to synchronism or the utilization of the energy of a weight upon a hoist in its descent to operate its motor as a generator which in turn will drive the continuous current generator as a motor and thus bring the alternator up to its synchronous speed. With such simple, efficient and cheap apparatus made by many companies to-day why should we wait for the solution of such difficult problems as commutators to stand 10,000 volts or alternating current motors which will be self starting and efficient, and at any speed and torque. Even if we had such motors it is evident that we must interpose some kind of converters to reduce the 10,000 volts to a reasonable pressure for applications in mines, and we would still require continuous currents for commercial arc lamps, storage batteries, electro-depositions, etc., and a special current for electric drills.

It seems to me that we should install a plant at the mine exactly as though we were going to drive it by a steam engine, and instead of doing so use the synchronous alternating current motor for this purpose and utilize as our original source of power the distant water power. In many instances, this method will be of especial value where it may be necessary for a few weeks in a year to fall back upon expensive steam power on account of the temporary failure of a distant cheap water power. If one comprehensive plant be installed of this alternating and continuous current type I believe an enormous development in this line will immediately follow and luckily the apparatus required can be turned out rapidly from any one of several large works without the delays incidental to the development of new apparatus and methods.

Mr. Stillwell was next called upon, and corrected the impression that he thought might have been received that American firms and engineers are not prepared for such daring attempts at power transmission as the Lauffen-Frankfort plant. He thinks that several American firms would undertake the same thing if they obtained such financial backing from the government as the German firms did. "I think that, beyond the combination of synchronous and direct current apparatus, and superior for most purposes, is, without question, the multiphase or two-phase alternating. As Prof. Thomson has very fully explained, it is adapted practically to every purpose for which we may use power, while it is equally adapted to lighting. Mr. Tesla's work in the direction of rotating fields, motors having rotating fields, is pretty well known; but it has been carried forward and perfected in a great many details since Mr. Tesla ceased to give it active attention. There are one or two points that are of interest with reference to the methods used at Frankfort. One of these is as to the comparison of the two-phase with the three-phase system. In the three-phase system the differences of phase between the three circuits is technically 120 degrees. In the two-phase system it is possible to produce a rotating field which will start motors with a strong torque intended to have a phase of 90 degrees. It has been found that where more than one motor is to be run, or where lights and motors are to be run, there is considerable difficulty in maintaining proper phase relations between the different currents of the three-phase system. The fact that in each of the subdivided circuits the relation of line resistance to inductive resistance will vary, tends sometimes to drive the current practically out of one of the wires. There is some reason to think, then, that a two-phase, 90 degrees system, would be preferable for combination work. The synchronous plant that has been referred to, which has been installed at Telluride, is one of considerable interest. The generator is one of a construction adapted to high potential, and delivers current to the line at a potential at about 3,300 volts. This potential was selected not with reference to the travel or distance (2¼ miles, which is the distance at which the only motor now operating is located), but with reference to a distance of eight miles, it being the intention to locate other motors at different mines along the range up to that distance. The work for which it is employed, namely the running of a stamp mill, is of a character where we do not care for varying torque and for varying speed. The motor runs practically all the time. It runs 24 hours a day, and at least six days in the week. I believe that, all delays figured in since the starting of that plant, the actual time it has been out of operation is only 16 minutes per day, all things counted in; and of the total delays, about 80 per cent. were due to difficulties in the regulating of the turbines. That suggests another point with reference to the operation, not only of two-wire synchronous systems, but of the three-wire. As Prof. Thomson suggested, it is certainly possible to operate even the three-phase motors as synchronous motors when the units are large. If there are no small units I can see no objection to doing that. You have the torque to bring them up to the speed, but when they are at the speed, let us have the advantages of the synchronous running, because there are advantages to that. For example, one of the difficulties in combining this kind of plant with the hydraulic plant is in regulation. If there is a thoroughly reliable turbine regulator on the market I have not heard of it. A great many circumstances will influence and alter the speed of the turbine, and rather suddenly; and if we run in synchronism, our entire load (the motor and all that it may drive, counter shafting, stamps in a stamp mill, or any other work that it may be doing) will act as a fly wheel for the turbine, and the effect is advantageous. It is exactly as if we had a line shaft running from our generator to our motor holding them rigidly together.

"With reference to using step-up and step-down transformers, it seems to me that they should be used only when the distance we wish to cover exceeds a certain amount. I do not believe that for a distance of less than 10 miles in general it would pay us to use them. They not only add to the complication of apparatus, but they necessarily add a considerable amount to the necessary investment, and if you admit them, the problem simply is to properly insulate our machine, and to provide for making the necessary changes of circuits without unnecessary or undue danger to those handling them. All these not only can be, but have been, accomplished. Switchboards are devised in which it is impossible for the attendant to touch either pole of the high tension circuit.

"There is another point which is somewhat interesting with reference to the three-phase as compared with the synchronous. One advantage of the synchronous system for certain plants, particularly for power plants in the West, is in the simplicity of the wiring. I have known at least one plant where fluid insulators were recommended, and were furnished by a manufacturing company, and were refused by those installing the plant for the reason that in the West the soil, or the rock, is so hard that they cannot cut it to erect their pole lines as they want to, and the consequence is that the poles are stuck up at all angles, and the fluid insulators ordinarily made are liable to spill the fluid; and they would not use them. They use instead an ordinary glass insulator with bare wire, and that is what is used at Telluride with over 3,000 volts successfully—has been used all through this winter, which has been a very severe one; which, by the way is a more severe and practical test than that which the Lauffen-Frankfort plan was submitted, although that worked at so much higher pressure."

Mr. Bradley, who was one of the earliest workers in the field of multiphase current motors was then called upon. He did not see any reason why the three-phase currents should not maintain their relationship just as thoroughly as the two-phase, which are 90 degrees apart. "Then there are some things about the three-phase currents that have not been mentioned; there are three wires and they can be led off into three separate circuits; that is, with six wires they may be led off and separate into three ordinary alternating circuits. The three-phase system gives a more even distribution of the magnetic field than the two-phase. I have worked with both, and have always thought that the three-phase has always proved to be more satisfactory to me than the quarter phase, as we call it (the two-phase). Of course there will be a great deal of controversy in regard to this, and there is a great deal still to be proven. We are as yet in our infancy in this, although we are trying to get the machinery ready as fast as possible to meet this work in this field."

Dr. Bell then made the following remarks:

"I am a little inclined to look at this matter from the point of view of the fellow who wants a power plant put in, wants it very badly, and wants it immediately. What can he get that will meet the necessities of the situation? There are many cases where the very simplest solution is to use existing direct current apparatus, inasmuch as the necessary voltage will not be over 1,000 volts; and if there appears to be excessive drop on the line, permit it and use 500 or 600 volt motors at the other end. There are plenty of cases where all the conditions of transmission, even of 1,000 or 2,000 horse power, can be met in such a straightforward way, and met on short notice, by half a dozen companies. That is one phase of the situation. Then we come to another phase of cases where the distances are considerable and yet not great—even small compared with that magnificent experiment at Lauffen. There we have the choice between several methods. We may use the very high pressure direct current, as has been successfully done in Italy over a considerable distance, or we may use the synchronous alternator; or polyphase alternating currents of any number of phases from two up to as many as you please. Now, the synchronous alternator has some advantages which I do not think should be forgotten, as when in the Telluride plant, on which Mr. Stillwell spoke, it becomes necessary to pick up a certain unit of power, and transport it bodily to be used in a single unit at another point, seven days in the week, the question of a self-starting motor then becomes of little importance. And then, finally, we reach extraordinary situations where powers must be transported a long distance, such a one, for example, as that from Niagara to Buffalo. And yet there is something to be said in favor of apparatus other than that which has been often suggested for the purpose.

"From the standpoint of the ordinary man, who is interested in the dollars and cents side of the problem, I fail to see the particular usefulness of raising your pressure to 25,000 volts for the sake of securing an outlay in the line of only $4 or $5 per horse power, when in order to do that you have to use a set of transformers costing $30 or $40 per horse power. It seems to me that a little less pressure and a little more copper put in the line would enable the transmission to be carried out at a pressure decidedly lower than 20,000 volts, with equal efficiency, and with the advantage of having the investment in copper, which does not deteriorate seriously, rather than transformers, which may, and sometimes do deteriorate. Of course there will be a point where it will be necessary to use the step-up and step-down transformers; but I think the fact ought to be emphasized that until distances become quite great it is a pretty even question between the cost of line and the cost of transformers, the advantages of durability being on the side of the line, the efficiency being the same, and the initial cost the same.

"In the present situation it does seem to me that a great

deal of the discussion between the defenders of the various systems forgets for a moment that much of what is to be done in the next year or two must be done under the conditions where we are working now. Much of it must be done with existing apparatus, and the man who will make the most thorough success of the transmission of power in that field is he who will attack each separate problem, doing the best he can with the apparatus which he can get, and not tying himself up absolutely to either continuous or direct currents, to two-phase, three-phase, or n-phase motors, seizes the opportunities for transmission of power as they come, and make the best of the situation with the best apparatus that that particular moment commands. It is this practical, commercial side of the problem which I think one is half apt to forget in the glory of electrical pyrotechnics." (Applause.)

Mr. Hering corrected a figure given in the above remarks, that instead of $30 to $40 for the transformer alone, the estimate given by the Oerliken company was $32 for *two* sets of transformers and the generator. Dr. Bell, however, claimed that his figures were obtained from the minimum price from a well-known transformer manufacturer in America. Several other members also thought that the figure of $36 per horse power for the entire plant, was very low as compared with American prices; Mr. Hering stated that he simply gave it as he had received it, and added that he thought it was low because the units were so enormously greater than anything heretofore used: the cost of a dynamo *per horse power* diminishes very rapidly as their size increases.

In a discussion which followed some members stated that the frequency of the Lauffen plant had been only 23 instead of 40 as reported, also that in wet weather the loss by leakage was very great. Mr. Hering who had seen the plant running successfully in a pouring rain, and who had received reports substantially by actual measurement, did not agree with that remark.

The discussion was continued by Mr. Stanley who said: It may be interesting to the members of the association to know that there is a line of 15,000 volts in operation in this country. We have constructed a small line at Pittsfield using 20 h. p. and fed by the station currents, the line starting at the outskirts of the town and making quite a little circuit. We find that there is practically no difficulty whatever at that potential. Fifteen thousand volts, however, is a very different matter than one, five or 12,000 volts. The striking distance at 15,000 volts is apparently two or three times what it is at 10,000 volts. For instance, if a wire hangs down from the line within an inch or two of the ground there is a most delightful aurora borealis between the ground and the wire; and if an ordinary dry pine board be placed in this circuit, it does not seem to affect the resistance a particle; the current goes right through it. We are making these tests at Pittsfield to become familiar with this question from a commercial standpoint, and have undertaken to transmit 400 h. p. for lighting purposes a distance of 28 miles in one place in this country. The delightful lecture given by Mr. Hering does not, however, give us some of the points which as engineers and as practical men we need in examining and testing the merits of the various devices. For instance Mr. Swinburne wrote me the other day, from information that he had received about the Dobrowolsky motor (a 2-h. p. motor) requiring 4,200 watts to run at no load and 14,000 watts, or ten times its rated capacity, to run it at full load. I do not mean that 14,000 watts are expended in the circuit, but I do mean that of the current apparently applied, viz., 14,000 watts, but 1,500 are actually useful. If this is an example of the engineering practice on the other side, I am very certain that my friend Mr. Stillwell can tell us that it is far below that obtained by Tesla. If I understand them correctly, the Tesla motor uses about .6 of its full load current to run it empty, .7 of which is usefully applied. That is to say, about $.7 \times .6 \times$ the total energy, is required to run the motor empty. The synchronous motor has certain very beautiful applications, but it has a very serious defect in my judgment; that is, when the motor is overloaded beyond a certain point, not only the motor stops, but it goes to pieces, it burns up; or is very liable to burn up. I do not see how any commercial system of distribution of power can be made when we have to start our apparatus by a weight as suggested by one gentleman; or by another motor as suggested by another gentleman; or by three special circuits which will not work in multiple, except they work alone, the plan suggested by Dobrowolsky.

In the case of the transmission of power between Niagara Falls and Buffalo I had occasion to visit Niagara Falls with the eminent engineer, Mr. Maxim, and while I am quite certain that 15,000 volts could be loaded on the circuit between that place and this, I am equally certain that no large amount of power can be transmitted successfully by the present apparatus; I mean with commercial success. If we are going to bring Niagara Falls to this city we have got to adopt some scheme radically different from anything that bas been presented up to the present, such as the scheme that Prof. Thomson suggested, and lay our wires at 100,000 volts pressure in an oil pipe. I cannot see that there is any half way solution of the problem.

Mr. L. B. Stillwell differed with Mr. Stanley, stating: His statements were really something new and revolutionary in order to attack this problem of transmitting power from Niagara to Buffalo. I think that we are to-day prepared to make an estimate, and to back it up with guarantees of operation, that will cover a plant which will bear criticism from every standpoint. There several alternative plans in fact which could be adopted with good results. I am quite confident we would use four wires on our poles instead of two, two wires carrying one current and two wires carrying the other current 90 degrees apart. The copper will be exactly the same amount as will be required by two synchronous motors, I have personally quite recently made an estimate and proposal, in behalf of the Westinghouse company, involving a number of hundreds of horse power, and a distance of a few miles greater than that from the Falls to Buffalo. In this instance, being an initial plant, we have been willing to guarantee operation for a period after installation, so I do not think that any one contemplating the erection of a power plant need wait until something new happens. As is well known, the efficiencies of all these motors are now very high. All these things are almost reduced to simple arithmetic; they are easily to be calculated, and do not involve factors so numerous or unknown as is popularly supposed.

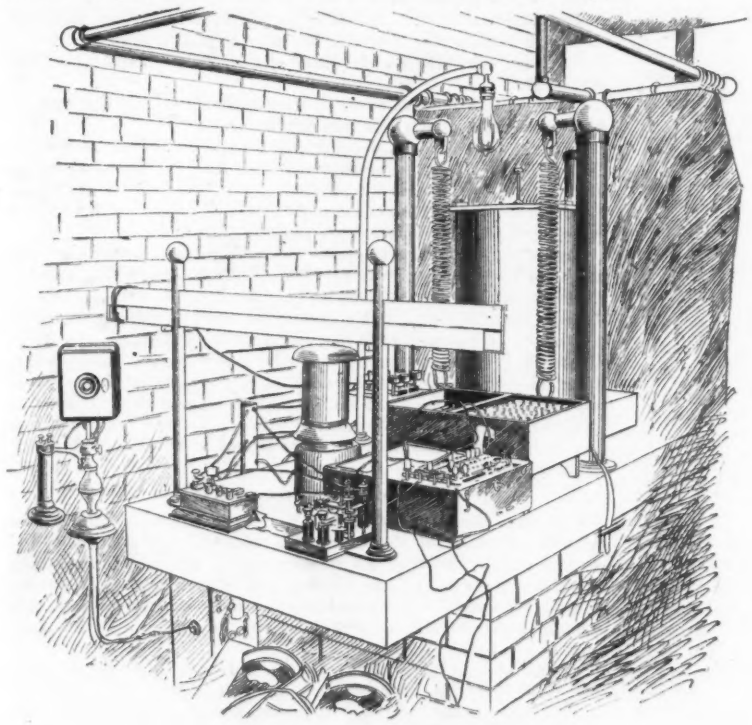


FIG. 4.—TESTING ROOM.

Underground Construction of the Buffalo Railway Company.*

BY J. B. CRAVEN.

Underground construction for railway use is becoming every day a more prominent feature of railroad construction. Overhead mains and feeders will not much longer be tolerated, especially in the larger cities, where already the common councils are making it part of a railroad franchise that feeders at least, shall be buried. The trolley wire, being bare, is of necessity left overhead, as safer and more economical, but it behooves us to meet this popular demand of placing all wires possible below the surface, otherwise we may be compelled to put the trolley wire itself there. Such an order would put the electric railroad industry back for quite a number of years, for not only would it be expensive, but, to my knowledge, no commercial underground trolley system has yet been put on the market.

Underground construction for railroad use brings us many problems to solve. While not using a high tension current, we have one side of our system always grounded, so that between the many miles of cables in use, and the earth we have difference of 500 volts; thus you see at once the necessity of having and keeping up the highest insulation possible. This question of ground return requires that the insulation resistance of a railway circuit be twice that of an arc or incandescent underground system, where you have a metallic circuit; then there are the constant and excessive strains that one does not meet either in arc or incandescent lighting, due to the throwing off and on of the cars. It is almost impossible to figure your feeders to carry the maximum current, so that at any time you are liable to have your cables overloaded, bringing very heavy strains upon them.

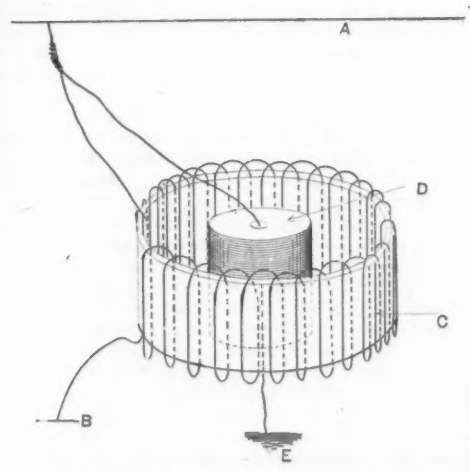


FIG. 1.—LIGHTNING ARRESTER.

Another question is the one of connecting overhead with underground wires. This brings lightning to the field to be guarded against, for the large surface of trolley wire offers an attractive path for lightning, and how to protect the underground feeders and mains has been quite a problem. Lightning has little regard for insulation, seeming to want a path only to earth; this path is offered by the underground cables, so that we have to introduce some arrester at the junction of the underground and overhead wires to give it some other path.

Fig. 1 shows by what means we hope to accomplish this end. *A* is the overhead conductor, *B* is the underground cable to be protected, *D* is a non-inductive path to the ground, *C* is a coil with an iron core grounded through a fuse. This you see will offer two paths to the lightning; one of very low resistance to the dynamo current, but very high resistance to a lightning discharge, due to its self-induction, the other a very high resistance to the dynamo current, but a very low resistance to the lightning discharge.

This arrester is placed inside a water-tight iron box on top of a pole, wherever tap is made with overhead wires; this box also affords a good place where overhead and underground wires can be connected and keep moisture from the cables; this is accomplished by wiping a three-inch lead cup on to the lead of the cable and filling it with insulating compound.

We have in this city about 11¼ miles of subways, divided into two trunk lines, which branch off, carrying feeders to the outlying districts. Our conduits are laid in cement 30 inches below the surface of the street. They are crowned in the centre, so that the water will drain to the manholes, which in turn drain to the city sewers, with a bell-trap to prevent sewer gas coming back.

Lately, on account of natural gas finding its way into subway and manholes, we have found it necessary to attach a blower at the station, which ventilates the whole system. Manholes we have placed every 400 feet, and have tried to make that distance standard, as pulling a greater distance brings an excessive strain on the cable when drawing in.

After careful consideration before this work was started, we decided to depend on our cable for insulation, not on conduits made of insulating material. To me it seems impossible to prevent moisture from penetrating the latter system, thereby lowering the insulati on. We depend on our ducts for mechanical protection alone

The cables in use here are lead covered, provided with an exterior fibrous jacket or covering saturated with pitch, the purpose of which is to protect the cables while being drawn in the duct. We have some 45 miles of cables, which have been in use since July last. These are of two classes—one for insulation depends on pure Para rubber, the other on a composition, our shortest feeder being two and a half miles in length, some of the longer ones reaching a distance of eight miles, yet the insulation on none at the present day is below 120 megohms, the short ones testing as high as 1,100 megohms. In laying this cable all tests were made in the testing room at the station; this was made feasible by the use of a telephone circuit throughout the underground system, so that a workman making a joint in a manhole was in communication with the man making the test and could always find out if his work was satisfactory. The joints made were the standard joints used by the companies from whom the cable was bought. A cut of these will be seen in Fig. 2, the lower one being the one used for the rubber covered cable, showing the consecutive layers of insulating tape; the first, which is next to the copper, being a narrow white tape, free from sulphur; then follows a layer of pure Para rubber tape; upon this is wrapped a layer of rubber compound, then a layer of black rubber, and around the whole is wound cloth tape of a sufficient thickness to entirely fill the lead sleeve; the ends of the lead sleeve are then dressed down and wiped to the lead covering of the cable with an ordinary plumber's wiped joint.

The upper cut represents a joint as made in the cable, using composition for insulation; the method here employed differed from the foregoing in that the lead sleeve is slipped over the completed copper joint, dressed down and wiped, the sleeve then being filled with compound through two small holes tapped through the top which are afterward closed permanently with a soldering iron; each feeder, for the purpose of tapping off branches to feed the trolley wire and to facilitate the breaking of cables in case of trouble, is run through a junction box (Fig. 3) every 1,000 feet. The box shown in the cut has eight stubs, which allows three cables to pass through and be broken, and two taps to be taken off for feeding purposes.

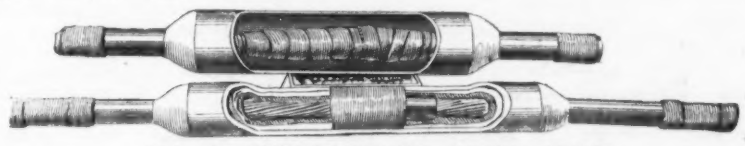


FIG. 2.—UNDERGROUND CABLE JOINT.

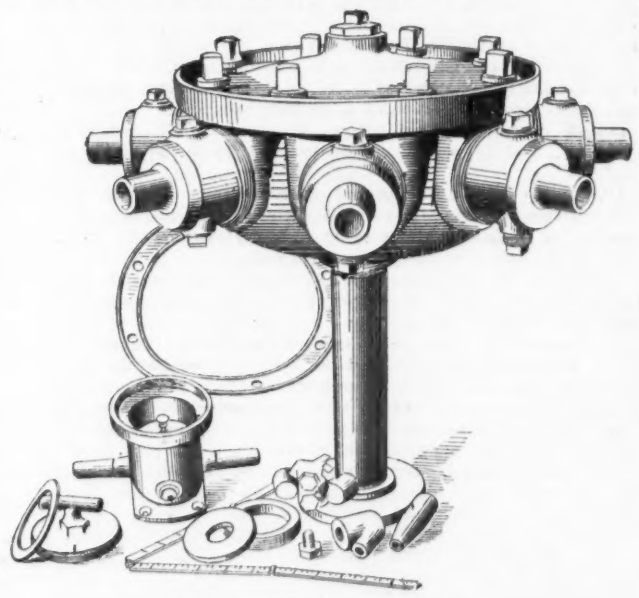


FIG. 3.—JUNCTION BOX.

A small telephone box is seen at the left. One of these is place in each manhole, the terminals of which are all in multiple.

A few words in regard to the testing of this system and the difficulties encountered on account of one side being grounded. We are obliged to test at night, when the load can be thrown off one feeder and on to another; then it is disconnected by means of a switch where it connects to the overhead, and the test is then made. It is rather a slow process, but the only one left open to us. Fig. 4 gives a general idea of the testing room, which is equipped with first-class instruments for practical use. The galvanometer, which is of the Thomson reflecting type, is inclosed within a magnetic shield made of wrought iron pipe, and also suspended by three springs to absorb vibration. The rest of the instruments consist of a chloride of silver battery, standard resistance and shunt and reversing key. To the left is seen the telephone communicating with the manholes.

Thus far we have looked upon the difficulties and disadvantages of the underground system. No arguments have been advanced in its favor, but I think you will agree with me that it has some. First, it does away with the public objection of disfiguring the streets, obstructing firemen in their duties, and, in the case of high tension currents, a menace to life itself; and then the liability of wires falling, causing a suspension of traffic, and, in case of a storm, causing a delay and loss of thousands of dollars to the company themselves.

*A paper read before the Buffalo Convention of the National Electric Light Association, Feb. 25, 1892.

The Operation of High Tension Currents Underground from a Physical and Financial Standpoint.*

BY E. A. LESLIE.

In presenting this paper, I shall endeavor to confine myself strictly to my own experience and observation, submitting only such data as I may have been personally able to collect, and leaving it to you to decide whether, it having been determined that the successful operation of high-tension currents underground is physically possible, the financial aspects of the case will permit its general introduction. Wasting no time in giving a history of the legislation which has brought about an almost complete revolu-

*A paper read before the Buffalo Convention of the National Electric Light Association.

tion from overhead poles and wires to underground conduits and cables in New York City, I shall proceed at once to facts and figures.

Conduits.

The underground conduits in New York City for high-tension currents are owned by the Consolidated Telegraph and Electrical Subway Company, who lease their ducts to the various electric lighting companies.

The prevailing type of duct is of iron pipe, mostly three inches in diameter, running along the sides of the streets into manholes about 275 feet apart. These are the so-called "trunk ducts." Over the trunk ducts are superimposed from two to four distributing ducts, with four-way handholes about 50 feet apart. Many of these handholes are brought to the surface of the street and are covered over with an iron plate, which is easily removable, giving ready access to the wires in the distributing ducts. In many places, however, the handholes do not approach the surface, and, in order to get at the wires to make changes or connections, it is necessary to dig up the street. Again, on some of the prominent streets no distributing facilities whatsoever have been provided and the companies are compelled to make long and expensive house connections from manholes. This is particularly true of Sixth avenue above Eighteenth street and Broadway above Thirty-fourth street.

The Subway Company have also a number of miles of a system which is made up of sectional iron castings and so framed together as to combine in one conduit both trunk and distributing facilities. These conduits have no surface handholes and, in order to make changes or connections, it is also necessary to dig up the street. The manholes are about 275 feet apart, as in the case of the iron pipe.

There is also a small amount of conduit in use, which is composed simply of cement-lined iron pipes, running from manhole to manhole, of about three inches inside diameter.

The cost of the New York conduits is an unknown quantity. The Subway Company guard the secret well, and, beyond the general statement that they have cost, on an average, nearly $5,000 per mile, per duct, no reliable information can be gained. In these figures, however, are doubtless included the expenses of years of legislation and long and costly litigation. It is the universal opinion among electric light men in the city that the actual average cost should have been less than $3,000 per mile of duct.

Cables.

The companies with which I a u connected use, principally, cables insulated with a rubber compound, although we also have in use 35 or 40 miles of cable, the insulating material of which is fibrous. Perhaps the best discription of cables I can give, is to embody herewith a copy of our specifications, which, with slight modifications, are in general use by the New York companies.

Specifications for Underground Cable.

Wire.—No. B. & S. (solid or stranded) must contain no joints or splices

Lead Cov ring.—To have an alloy of from four to five per cent. tin. Thickness of lead, $^{2}/_{32}$.

Insulation.—Outside diameter, 32ds (usually $^{5}/_{32}$ to $^{7}/_{32}$ all around the conductor). Resistance of insulation without lead covering, after at least 48 hours' soaking at temperature of 75 degrees Fahrenheit, 1,500 megohms per mile. Resistance dry test with lead cover and without lamp connections, 1,500 megohms. Resistance of insulation after three years' use to be up to the standard required by the Board of Electrical Control, which is not less than five megohms per mile, per 100 volts of current employed up to, for example, 3,000 volts *i. e.*, 150 megohms.

Copper.—Conductivity of copper, 98 per cent. To be medium hardness; that is to say, a mean between hard drawn and soft copper.

Diameter.—Outside diameter of cable, including lead covering, 32ds (depending upon the size of the wire). Electrical tests of insulation to be made at factory by company's representative. If insulation is taped, outside diameter of cable to be 32ds.

Capacity.—Cable shall be capable of carrying an alternating current of —— volts and —— ampères; or continuous current, —— volts and —— ampères.

Laying and Connecting.—The cable to be laid and connected by the Electric Light Company under the supervision of the manufacturers, who shall carefully supervise the work, and, after accepting the same, shall be liable under the guarantee, in the same manner and to the same extent as if they (the manufactures) had themselves laid and connected the cable.

It is usual for manufacturers to guarantee their cables for a term of three years. As the form of guarantee may also be of interest, I quote that with which I am familiar in its entirety:

Guaranty.—Whereas, The Electric Light Company, a corporation duly incorporated under the laws of the State of New York, has purchased from feet of electric light cable, as called for by the annexed specifications, which are hereby made part of this guaranty.

Now, therefore, in consideration of such purchase and of other valuable considerations to us in hand paid, the receipt of which is hereby acknowledged, we, a corporation duly incorporated under the laws of the State of , do hereby guarantee and warrant the said cable to be a satisfactory practical working cable for the purposes and currents specified in the said specifications, for a period of three years from the date of its being put into use. Nothing herein contained, however, shall be deemed as a guaranty or warranty by us for any failure of said cable due to the use of the current in excess of that referred to in said specifications, or for failure due to mechanical injury from improperly drawing into the conduits and improper connections of the said cable.

In the event that the said cable or any part of it fails to meet the requirements of this guaranty or warranty during the term thereof, we hereby covenant and agree to replace the cable so failing with cable that shall meet the said requirements during the term of said guaranty or warranty, the cost of replacing said cable to be borne by us.

In the event of any failure of said cable being discovered by the said Electric Light Company, we, the said shall receive prompt notice thereof, and hereby covenant and agree to forthwith investigate and test the cable so discovered to have failed; and if it shall appear that such failure was not due to the causes herein specifically excepted, then we, the said covenant and agree to bear the expense of such investigation and test, and of replacing the whole or the failing portion of said cable; but otherwise, all such expense shall be borne by the Electric Light Company.

Whenever such investigation and test may become necessary, said Electric Light Company shall furnish unto us, the said such facilties and information as are within the control and knowledge of the said Electric Light Company, relating to said cable, the circuits in which they are made up and the use thereof, together with access to manholes and terminals, so far as controlled by the said Electric Light Company.

In Witness Whereof, etc., etc.

The cost of lead covered cables, such as the above specifications call for, varies considerably, according to the size and manufacture. Roughly speaking, however, No. 4 cable ranges from 15 to 20 cents per foot, or from $792 to $1,056 per mile. No. 2, from 25 to 30 cents per foot, or from $1,320 to $1,584 per mile. No. 00, from 37½ to 45 cents per foot, or from $1,980 to $2,376 per mile. No. 0000, from 55 to 65 cents, or from $2,904 to $3,432 per mile. In other words, underground conductors cost from four to five times as much as overhead conductors, which is a matter to be carefully borne in mind.

Laying.

The manner of laying cables is simple. It is first necessary to draw a rope through the duct to be occupied. To do this, rods about three feet in length are used, having brass male and female screw attachments, one at each end. The first rod is inserted in one end of the duct; then another is screwed into it and pushed forward, and this process is continued until the first rod emerges into the manhole at the other end, and you have an unbroken line of connecting rods through the duct. A rope is then attached to the last rod, and, as the rods are pulled forward and unscrewed in the manhole at the distant end, the rope is gradually drawn through. Unless a large number are to be drawn into a single duct, they can be drawn by hand without any special machinery. If, however, it is desirable to draw in as many, at one time, as the duct will hold, it is necessary to use a winch or windlass, or, in lieu of either, a snatchblock with a rope and tackle, and enough men to pull the mass. Great care should be observed not to allow the cables to twist in the duct, as, if this occurs, it is next to impossible to withdraw any given conductor thereafter without removing all conductors in the duct. In cutting the cables to fit given sections, about 12 feet should be allowed for slack between manholes, for racking around the sides of manholes and for metallic joints. The cost varies considerably. To draw in two cables in a duct would cost in the neighborhood of from 2½ to 3 cents per foot of cable; but to draw in four or six, or even eight, as has frequently been done, the cost diminishes and will not average over two cents per foot, or even less, assuming that the men in charge have had experience and understand their work thoroughly.

Jointing.

The proper jointing of cables is a matter of paramount importance. Unless the joints are made by an experienced person, it is almost impossible to secure a joint which will give the same insulation resistance as the cable itself, and yet, unless the joints are so made, the object of securing immensely high insulation in the cables proper is entirely defeated and a large proportion of the original investment practically wasted.

The New York Subway Company, in its early inception, framed a set of rules governing the operation of underground conduits. Among them is one which has always challenged my admiration, and the man who framed it either built wiser than he knew, or was a remarkably gifted person. This rule at first was considered absurd and impossible of compliance, but to-day I think I am safe in saying that every electric light company governed by it will acknowledge its wisdom and admit that, by having enforced a high standard of insulation from the very outset a large amount of subsequent experiment and waste of money has been avoided. I quote the rule:

Section 4. Electromotive Force.—"All conductors drawn into and operated in the conduits, and intended to convey currents of an E. M. F. exceeding 100 volts, shall have at the temperature of 75 degrees Fahrenheit, an initial insulation resistance of not less than 15 megohms per mile per 100 volts E. M. F. of current in the circuit. Whenever the insulation resistance of a conductor as aforesaid shall prove to be less than five megohms per mile, per 100 volts, the use of that conductor shall at once cease, unless the actual E. M. F. in its circuit be reduced so as to re-establish the foregoing ratio."

You will observe that the initial tests of cables laid by any of the companies in New York City must show an initial insulation resistance of not less than 15 megohms per mile, per 100 volts of current used. This means that, with an alternating current of 1,000 volts, the cable must show, before the current is turned into it, to have an insulation resistance of not less than 150 megohms per mile, with an arc circuit of 2,500 or 3,000 volts, or even 4,000 volts, initial insulation resistance must not be less than 375 megohms, 450 megohms and 600 megohms respectively. Taken into consideration with the fact that on an ordinarily humid day, overhead circuits will not show an insulation resistance of more than from 200,000 to 500,000 ohms per mile, the above requirements seem altogether impossible of attainment and to be ideal rather than practical, but this is not the case. On the contrary, it is rare, indeed, that the initial tests of cables laid in New York city, do not show from three to four times the initial insulation resistance required by the rule, and, of the hundreds of miles of cable actually in operation at the present time, and which have been in operation from two to three years, and with which I am personally familiar, I do not believe that there is one that will not show, under like conditions, nearly, if not quite the same high degree of insulation as when the original test was made. I fact, I have proved this to be true many times, and will cite one of our latest tests.

Initial test, Nov. 17, 1889.—Weather, clear; temperature, 60 degrees Fahrenheit; constant, 33,000. Leg No. 1: Length, .95 mile; deflection of galvanometer 25 divisions; total insulation resistance, 1,320 megohms; insulation resistance per mile, 1,259 megohms. Leg No. 2: Length, .95 mile; deflection of galvanometer. 20 divisions; total insulation resistance, 1,650 megohms; insulation resistance per mile, 1,567 megohms.

Last test, Feb. 5, 1892.—Weather fine; temperature, 25 degrees Fahrenheit; constant, 33,000, Leg No. 1: Length, .9 mile; deflection of galvanometer, 12 divisions; total insulation resistance, 2,750 megohms; insulation resistance per mile, 2,475 megohms. Leg No 2: Length, .9 mile; deflection of galvanometer, 10 divisions; total insulation resistance, 3,300 megohms; insulation resistance per mile, 2,970 megohms.

It is, of course, apparent that the conditions under which this last test was made were much more favorable than in the case of the initial test, but I think it is also apparent that the insulation resistance of the cable has suffered little or no deterioration after more than two years of constant use.

This would be impossible with poorly insulated joints. The first cable laid by the Manhattan Electric Light Company on Broadway was insulated with rubber compound, and the joints were made by contract on the representation of the contractor that his men were professional jointers. After the cable was connected throughout a test showed less than a megohm of insulation per mile, and this bad condition of things was quickly shown to be in the joints; every one of them had to be cut out, and our lesson was well learned. Since that time we have never allowed any but our own men, specially trained and educated for the purpose, to make joints on rubber-compound cables. I once wrote a gentleman regarding joints, that, in making each and every one of the thousands of joints in use, we have observed in every case the same care and precaution in making them as is observed by the Atlantic Cable Company in repairing breaks in mid-ocean, where, in such cases, it used to be the custom, before they maintained their own ships, to charter or equip a vessel to reach the locality of the break, the cost of which ran anywhere from $40,000 to $60,000, and where this whole sum was dependent upon the making of one first class joint. This may sound like an exaggeration, but, nevertheless I can assure you that our extraordinary precaution has saved us an unknown, but large amount of trouble and, on that account, our almost total immunity from interruption is largely due. The cost of joints will run from $2 to $3 apiece and any manufacturer can give proper directions how to make them and what to use, both as to metallic contact and insulation, but, in the case of the rubber compound cables, the difficulty lies more with the man than with the method. Men whose hands are naturally moist cannot make a good joint, *i. e.*, a joint which will test "infinity."

Testing.

We are required to test all underground circuits at least once per week. For this purpose a portable reflecting galvanometer is used. Where the cables enter the station a test room, free from the jar of the building, is usually provided in which to set up the instruments; but in cases where the cables are reached from the station by overhead wires, it is customary to rent a quiet room adjacent to the junction pole and connected by a well insulated "lead" for permanent use. The total insulation of a circuit with all converters or arc lamps connected will generally fall below the requirements of the rule above quoted, but unless it is shown to be less than say one megohm per mile of cable, its condition as a "completely connected circuit" is usually accepted. But as a general rule when the insulation falls below this standard, what are termed "ex-converter" and "ex-lamp" tests are called for. These require, in the case of incandescent circuits, that every converter installation be cut out, the cable ends freed from all contact and tests of cables only be made to ascertain their exact condition. The arc circuits are similarly treated by disconnecting all lamps and switches. Unless the results of such tests come within the limits prescribed by the rule, the circuits are not allowed to be operated until the defect has been removed and the insulation brought back to the required standard. Fortunately defects are rare and tests of this character are not now called for with sufficient frequency to prove burdensome.

House Connections.

House connections are built by the Subway Company at the expense of the electric light companies; but the Subway Company claims not to relinquish ownership therein and will not allow their joint use by two or more companies except by special arrangement. The cost of house connections in New York City is appalling to the man of exclusively overhead experience I will quote a few selected at random:

(The author then gave the actual costs in a number of cases, of which only the averages are given here.)

First.—On upper Broadway. No distributing facilities except from manholes. Average (of the four cases): house pipe, $118; cable and labor, $62; total, $180.

Second.—On upper Sixth avenue. Same as above. Average (of the four cases): house pipe, $121; cable and labor, $70; total, $191.

Third.—Many of the streets have subways upon one side only. House connections from handhole boxes to the opposite side of the street are long and expensive. For instance (average of the four cases): House pipe, $130.

Fourth.—Distribution to side of street on which conduit is laid or where there are distributing facilities on both sides of the street. (Average of the eight cases): House pipe, $25; cable and labor, $23; total, $48.

Fifth.—The cost of connections to city lamp posts, including pipe, cable and labor, averages about $110 per post.

You will observe that, in some cases, the cost of these connections exceeds the gross revenue derived fro an arc lamp for an entire year, but, unless we resolve not to develop the particular territory in which these cases occur, we are obliged to invest our money and take chances for the future.

Fortunately, it often happens that one house connection will serve for two or three different installations, and in this way the average cost per installation or per arc lamp is very largely reduced. For instance, in the fall of 1890 our arc lamp connections cost us, on an average, only $43; in the spring of 1891, an average of about $30; the ratio of new connections to new installations or lamps being as one is to two. In other words, for 100 installations or lamps we were required to make but 50 house connections. This ratio could be largely and safely reduced were we allowed by the authorities to use more than 100 feet of overhead wire with each underground connection.

Some Features of Underground Operation.

It is a fact worth knowing that the underground service is more reliable than that of the overhead. Storms, blizzards, sleet and wet snow have little or no effect upon it, and neither has lightning, where the circuits are entirely underground. In consequeace, cases of interruption are rare; crosses never occur; grounds but seldom, and open circuits are unknown, except when a break occurs at a lamp or switch.

The number of "burn outs" in the subways is small, and thus far, after three years' experience, not a single instance of burn out has occurred in our "rubber" compound cables that has not been directly attributable to some imperfection of manufacture, which originally escaped detection, or to mechanical injury after the cables were laid. And these have not amounted to more than 10 or 12 all told. We have, however, had several instances with the "fibrous" compound, but whether due to accidental abrasion of the lead covering, which is fatal to that form of insulation, or to some inherent defect, we were unable to determine, as the intense heat of the escaping current destroyed all evidence in each case.

During the first year of our experience we suffered considerably from mechanical injuries caused by the carelessness of employés of other companies having common access to the manholes with ourselves, and I, presume our own men were equally culpable as regards the property of our neighbors, but the common experience of the companies suggested greater care and consideration upon the part of all, and, by carefully stowing the cables away upon racks built along the sides of the manholes, mechanical injuries have now become exceedingly rare.

On wet nights we have an occasional case of trouble in a leaky switchbox or at an exposed joint, where the wire running to the lamp is connected with the cable. These joints were at first covered with ordinary tape, but after a few months' exposure the tape would invariably leak under the high pressure and sometimes convey the current to the lead covering and result in a burn out.

In the case of rubber compound cables, we now simply cut back the lead a few inches, strip off the taping, make an ordinary metallic joint and then slide over the bare metal a floor insulator, open at both ends, and standing upright so as to allow the rain to run through the lower end; the insulator resting upon the rubber compound, not upon the lead covering of the cable. This, of course, refers only to lamps where switchboxes cannot be used, such, for instance, as city lamps. Where fibrous cables are used, a regular insulating joint of pure rubber is made, connecting to a short piece of specially insulated wire. The joint is immersed in boiling hot paraffine and the specially insulated wire is then connected in the ordinary way to the wire running to the lamp. This is done to protect the insulation of the cable from moisture and also to facilitate connecting and disconnecti g with the lamp, which the regulation tests frequenty render necessary.

In laying cables it has been found desirable to place both "legs" of incandescent circuits in the same duct. When they are separated to different ducts great loss results from self-induction.

The use of the subways makes it possible to employ much heavier single conductors than could be used overhead. There are in some

of the ducts conductors having nearly, if not quite, 500,000 circular mils area, and such sizes as No. 00 and No. 000 are quite common. The conductor being composed of small wires stranded, affords sufficient flexibility for all purposes; but in sizes up to and including No. 2 B. and S., the conductor is generally solid.

In the matter of public safety, the records of the past three years show but one death to have occurred from current conducted underground, and that particular case occurred on top of a city lamp-post on a wet night, the victim neglecting to use his gloves. Prior to 1891, deaths caused by shock from overhead wires occurred with considerable frequency—sufficiently so to arouse great public excitement and hasten the burial of the wires underground. But it is fair to state that more than nine-tenths of all the accidents were primarily due to the inferior character of the overhead construction and the extraordinary multiplicity of wires of all kinds in the streets.

The arrangement of the underground system is exceedingly cumbersome, that is to say, it requires much greater time as compared with overhead methods, in the construction both of trunk lines and house connections. Under the old overhead system an order for an arc lamp, for instance, could be executed within two or three hours after its receipt, and the whole cost of hanging was not to exceed anywhere from $8 to $12. Now, however, in order to hang an arc lamp and connect therewith, it is necessary to make formal application to the Subway Company for the house connection, and this requires, on their part, anywhere from 3 to 10 days' time. After receiving due notice that the house connection has been built we are then required to apply to the Board of Electrical Control for a permit to hang the lamp and connect it with the underground conductors. This requires additional time, amounting to from 3 to 10 days, often two weeks and even longer; and, in a number of instances, before we were finally permitted to fill the order, the prospective customer had become disgusted with the delay and canceled his contract. The Subway Company has also to apply to the Department of Public Works for a permit to open the street and must receive the same before they can proceed with the work making in all three distinct applications to three different bodies for each house connection.

Again, the underground system rigidly circumscribes the territory in which current can be distributed to the streets through which subways are built. Lights cannot be served 200 or 300 feet off the line of the subways without a long underground connection, the cost of which would, in nine cases out of ten, prove prohibitive.

I recently read an article in a Western newspaper, to the effect that the wiring of the plant located in the city in which the paper was published, was all overhead, because the underground systems in New York City and elsewhere had proved to be a failure on account of gas explosions, which were so serious and frequent in their nature as to make the operation of high-tension currents underground infinitely more dangerous than dynamite. Now, as a matter of fact, although it is true that the earth beneath the street pavements of New York City is completely saturated with gas, but very few explosions have actually occurred and those not at all serious in character. Only one interrupted our business, and in that case, only a few hours and on but two circuits. The Subway Company use a system of blowers, which keep the subways reasonably free from gas, and this source of danger or interruption, at least so far as the city of New York is concerned, may be wholly disregarded. Nevertheless, without the blowers it might be reasonable to apprehend danger.

The Financial Aspect.

A good system of underground conduits fairly covering the electric lighting territory of a large city will, in my opinion, cost on an average from $2,500 to $3,000 per mile per duct, but in the case of a single duct in a trench, the latter figure is likely to be exceeded, depending largely upon the character of the digging and the engineering difficulties to be overcome. For the purpose of comparison, however, let us assume $3,000 to be the cost of one mile of distributing duct and then consider the cost of one mile of construction for one arc and one incandescent circuit, by both underground and overhead methods, as follows:

UNDERGROUND.		OVERHEAD.	
Duct	$3,000.00	50 poles prepared and set at $12	$600.00
11,000 ft. No. 4 cable at 20 cents, laid	2,200.00	11,000 ft. No. 4 wire, at 4½ cents	495.00
11,000 ft. No. 2 cable at 30 cents, laid	3,300.00	11,000 ft. No. 2 wire, at 7¼ cents	797.50
40 house connections at $75	3,000.00	40 house connections	480.00
Total	$11,500 00	Total	$2,372.50

Hence, from these figures, it must be assumed that the initial investment for an underground system will exceed by about five times the cost of an overhead system, and the fixed charges on this very expensive feature of investment in a central station plant must be correspondingly increased.

But in New York City, as before stated, the underground conduits are owned by a subway company, who have an exclusive franchise and who lease their ducts to the various electric light companies upon the following schecule of rentals;

Distributing ducts,	$1,000	per mile	per duct	per annum.
Trunk ducts, 3 inch,	900	"	"	"
2½ "	800	"	"	"
2 "	700	"	"	"
1½ "	550	"	"	"

These rates have the effect of increasing the usual and ordinary expenses of a central station enormously, and, although some overhead wires are still in service, and our field of operation is almost wholly confined to the more important streets and avenues, *the amount of the duct rental already equals the combined cost of coal, water, oil, waste and the salaries of chief engineer, engineers, firemen, coal handlers, boiler cleaner and oilers, employed in the engine department.*

The development of electric lighting territory is, consequently, much restricted, and streets which would offer fair inducement for overhead wires cannot be considered at all from an underground standpoint. A case of this kind occurred in our last bidding for street lights. A certain company bid for the lights on Fifth avenue, between Twenty-third and Forty-second streets, about 15 in all, at the rate of 60 cents per light per night. This was 20 cents above the ruling price. Being called upon to explain, the company stated. First, That there was no commercial arc lighting to be had in that locality whatsoever, and they must rely solely upon the street lights for revenue; second, That there were subways on both sides of the street and that, as the lights were distributed on both sides of the street, they would be obliged to lease a duct on each side; third, That, therefore, the duct rental "on Fifth avenue alone" would amount to "32 cents per light per night."

There is another onerous feature which discourages the extension of territory, and that is, that the Subway Company requires us to execute a bond agreeing to pay rental for a term of five years on all new ducts constructed, and this bond must be secured by collateral of unquestionable value. This insures the return of their capital, even at their own estimate of cost, but it imposes a heavy burden upon the electric lighting companies.

And right here it seems pertinent to remark that I have long been convinced that it is a matter of paramount importance to an electric light company to own the subways it occupies and to possess the right to extend the same as the development of its business may require.

While I have no complaint to make against the Subway Company of New York, I know that the subways could be operated by the companies for much less money than they are now required to pay, taking into full consideration the matter of interest on capital investment, cost of maintenance and operation, and every other charge which can be justly considered. Therefore, for those ot whom opportunity is yet given, it might be wise and prudent to at least secure the right to construct underground conduits, even although they may not adopt their use for some time to come.

As to maintenance, our experience with cables has not been sufficiently great to give us a definite idea as to their possible life. Aside from this, however, it costs no more to maintain the cables than it does to keep overhead wires in good order, say from $15 to $20 per mile per wire per annum—probably not quite so much; but, unless the cables last at least 20 years, the cost of maintenance is likely to be far greater.

FIG. 1.—THE TANNING OF LEATHER FOR DYNAMO BELTS.

Finally, summing up the whole situation, the following conclusions may be fairly reached.

First. The underground service is not only a physical possibility, but an established fact upon a very large scale.

Second. It is less liable to interruption than overhead wires.

Third. It is less dangerous to human life.

Fourth. Its cost is enormously greater.

Fifth. It is cumbersome to a degree and lacks, to a considerable extent, the flexibility of overhead wires.

Sixth. Its cost precludes its extension to sparsely lighted districts, which must either be reached overhead or permanently abandoned.

In the discussion which followed, Judge Armstrong praised the paper very highly, agreeing that it was really a question for the public whether they will put an enormous sum of money into these subways (for it is the consumer that must pay for it), or whether they will put it in their pockets. Not one out of ten companies could live if they had to go to the expense of putting the wires in these subways, at the enormous expense which it entails.

Mr. A. G. Brown, after giving a brief history of the various things which led to putting the electric light wires underground in New York City, said in reference to the present conduits that only 45 per cent. are now occupied, the commission having designed to build for future needs. He concluded by saying: "There is no doubt as to the great advantage of the underground system, and I firmly believe that in the future the necessities of the case will demand underground electric communication and power transmission."

Mr. Cushing mentioned that the World's Fair will have a subway plan for the distribution of its main wires; it will be a large affair, eight feet high and four feet wide.

From the Tannery to the Dynamo.

BY CHAS. A. SCHIEREN.

[In a detailed description the author follows the hides from the slaughtering establishments through the various processes they undergo in the tannery to the final operation of cutting and cementing together to form belts. In the accompanying cuts some of the views of the inside of a tannery are shown. In Fig. 1 the operation of unhairing the hides is shown, while Fig. 2 is a view of the "lay away vats" and hides as they are trimmed.]

It may be of interest to engineers, and the electric light fraternity in general, to learn something of how leather is tanned, and the

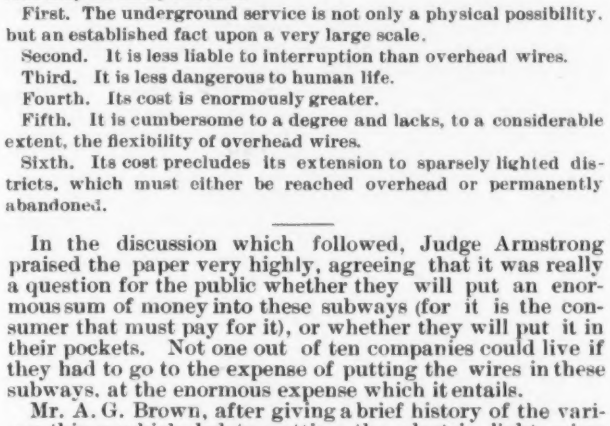


FIG. 2.—THE TANNING OF LEATHER FOR DYNAMO BELTS.

various processes through which a hide passes before it is tanned and curried ready to be put into belting.

After giving a very interesting and detailed description of the various processes which the hides undergo, and how they are finally made into belts, the author states:

Rivets are now rarely put into belts; a double belt well cemented is good for all ordinary purposes, and rivets are superfluous; however, certain fastenings, such as endless copper wire screws, which do not obstruct the surface or unnecessarily stiffen the belt, are a benefit; especially when the belt comes in contact with water or too much oil, this fastening prevents the belt from coming apart, and holds the leather firmly together.

All main driving belts over 40 inches in width have to be made in sections, consisting of two or more pieces of leather cemented together; the average hide for belting does not contain more than 40 inches in width of solid leather suited for belting, very rarely over that; therefore, wide main belts are made in sections. Ordinarily the pieces are not lapped parallel, but simply butted. For example: A 60-inch double belt receives two 30-inch pieces for the first layer, laid side by side, and a 30-inch piece over the centre of the two lower pieces to break the joint, and two 15-inch pieces on top of each edge of the lower layer to complete the width; thus the belt is cemented together. However, for electric light plants where belts are run at high speed and with variable power (which produces sudden strain), the seam of these butted joint belts, in several instances, broke, doubled up and destroyed the belts completely. To guard against such a calamity it is considered advisable to make wide main driving belts with parallel joints. For example: A 60-inch double belt will be made of two 33-inch pieces joined parallel, with a 3-inch lap, making one solid piece 60 inches in width, and on the upper part put a 33-inch piece in the centre and two 18-inch pieces on the edges, all joined with parallel laps; this cemented together will make a 60-inch double belt with unbroken surface, and as one solid piece of leather having a uniform tension and able to withstand an equal strain over the belt transversely as well as parallel, and thus will prevent such large, heavy driving belts from collapsing at the parallel joints. Every one must admit that main belts made on this plan are superior and more reliable, and would come into general use if it were not for the additional cost of labor and material in making them.

Leather being by nature an absorber of moisture, belts must be guarded against exposure to oil. In electric light and power plants much mineral oil is used, and the great velocity at which the belts are run seems almost imperceptibly to suck or draw the oil from the journals of the engines and dynamos, and allow it to be absorbed by the belts, which get completely saturated with oil, and in a short time rot and destroy the fibre of the leather. Various methods have been used to overcome this difficulty. One of the most successful is a certain composition or belt dressing which is rubbed over the surface of the belt, and closes the pores of the leather. No foreign substance can penetrate a belt treated with this compound, and the belts last much longer and give better service. With perforated belts this compound does not seem to be so effectual, because the perforations naturally expose the inner part or the heart of the leather, which is very porous; however, the surface of the belt being covered it shields that part of the leather which comes in contact with the pulleys, and the current of air passing through the perforations protects the belt to a certain extent, and that class of belt runs smoother, with less friction and is more reliable.

And now, gentlemen, we have reached the point where another curious and erroneous idea prevails among many engineers, namely, that belting should be made of pieces only four feet in length, as if all hides were of the same length and texture; it will surprise these men to learn there are no two hides alike, they vary in some particular point. Hides exist which will make almost six feet of sound solid leather below the shoulder, and again some hides will not make four feet of solid length; the only safeguard is to specify belting made of leather cut below the shoulder of the hide, irrespective of length.

In the discussion which followed, Mr. Perry, in referring to the last clause, asked whether it would not be difficult to detect failures of the belt manufacturer to comply with the specifications if they were worded as suggested, instead of as usual, namely, to be limited to four feet lengths. Mr. Schieren replied that it would be necessary to trust the manufacturer; he thought that any reliable firm would not risk their reputation by taking advantage of such a clause, to the detriment of their goods.

In answer to a question whether there is any choice in the placing of the leather; whether it is better to place the heads all in one direction and the tails in the other, or whether there is any difference in putting the grain of the leather irrespective of the direction of the belt and the direction in which it is running, Mr. Schieren said:

"In order to make a straight line belt we have to use heads with heads, if the belt is made of anything else than centres. In using centres this is not necessary, as the centre is perfectly straight, and it is only by the greatest stupidity on the part of the workman that you can make it crooked. If we had to make all our belts from centres, it would not be done. In making belts of other than centres there is a right and left, and the workman must be careful not to change the relation. Crooked belts often come from the fact that the workman will put a left on a left, and then again a right on a left. The joints should be made shoulder on shoulder and butt on butt."

Underground Conduits and Wires.*

BY M. J. FRANCISCO.

[The first part contained a copy of the circular which was printed and mailed to the central stations and other parties using underground conduits, asking for information regarding the use, operation and success obtained. But as this was found to be unsatisfactory they then made personal investigations, which they report in detail. Most of these reports were decidedly unfavorable for the underground systems, being an almost unbroken record of failures; in a few cases where no failures were reported, the cost of the rental was considered exorbitant. Among the systems described, the following have some points of interest.]

In Washington the terra cotta conduit is used. This is a trough of joints three and one half by eight inches, made of glazedterra cotta, laid with a proper cover about two feet below the surface; these are connected by bracket-shaped pieces, which hold the joints in position, and all laid in a heavy bed of cement; each duct is calculated to hold three two-inch cables, but the size can be varied. The electric lighting company tried conduits of wood, asphalt and iron, but they all failed; they then used the terra cotta and have found it very satisfactory and reasonable in price, but the cable to be used must be first class.

In Liverpool the mains are laid in cast iron troughs, then filled in around them with bitumen and covered over with Portland cement. These have answered perfectly for the low tension, but they have not used high tension currents long enough to test their efficiency of durability.

In Bath, England, they use a conduit consisting of an iron trough, with iron cover, in which cables with one-half inch insulation are laid on wooden bridges about two feet apart, and after the cables are placed in position the whole is filled solid with bitumen and then the iron cover fastened down. On cables laid in this way, they have carried for two years an arc current of 2,500 volts and an alternating current of 2,000 volts successfully, only one ground having occurred.

The general conclusions arrived at by the committee were as follows:

After a careful and extensive examination of nearly all underground work in this country, the fact has been developed that, with very few exceptions, the system and plans heretofore adopted have proved a failure; in some cases caused by improper materials, or insufficient insulation, in many cases by carelessness in laying the

*Abstract of a paper read before the Buffalo meeting of the National Electric Light Association on Feb. 24, 1892.

* Report of the committee of the National Electric Light Association read at the Buffalo convention, Feb. 23, 1892.

conduit or drawing in the cable, and in a large majority of cases from using cable with too thin an insulation. High tension currents can be carried in conduits successfully, if the conduits are properly built and cables thoroughly insulated and carefully drawn in; but it is absolutely necessary that all work and materials should be first class, no half way business or effort to scrimp and save expense by thinly insulated cables or poor construction.

Investigation plainly shows that a large number of the troubles on underground cables have been caused by workmen in the manholes, as the employés of all companies have access to same. Employés of one company have been extremely careless while working over the cables of a competing company, and trouble has followed. This shows conclusively that each company should own and control exclusively the conduit in which its wires are placed. The plan of renting conduits is not productive of good results, unless the legislatures of the various States pass a law regulating the charges made for rental, and this should be the aim of the National Association to see that laws properly controlling the price charged for rental and use of conduits are passed in all the States where they are used.

A serious trouble in underground work has been caused by drawing in the cables. This is a very important part of the business and should only be intrusted to reliable and experienced men, as the least injury to the insulation, while it is being placed in the duct, will surely develop and cause trouble, and many of the burnouts have been caused in this way. No matter how good an insulation you may have, if it is cut or injured while passing it into the duct you can depend upon it that this special place will give you notice before long, and in a way that will severely test your ability to obey one of the Ten Commandments.

Some substance must be used for the conduit that will withstand the action of the gases, soil, etc., and also resist the affectionate embrace of the Irishman's pick, used in excavating and repairing streets. Iron is not desirable, as under certain conditions and places it will be destroyed in a few months, leaving your cable exposed; cement alone cannot be relied upon; wooden conduits soon decay, besides absorbing large quantities of moisture. It would seem that glazed terra cotta, or a like substance, set in concrete the most reliable, and with a cable first insulated with not less than one-quarter of an inch of pure rubber, this covered with a heavy braid well insulated, over this a covering of lead, and then a heavy and substantial braid, saturated with a good compound, will give satisfactory results, and can be used with high tension currents successfully and without being troubled with burn-outs or grounds. But this entails a large outlay for conduits and cables.

There is one feature of the business upon which all examinations and reports agree; that is, that the underground plan has been in use for so short a time that it is impossible to give a fair comparison of the cost of maintaining aerial and underground circuits, but it is conceded that the expense of maintaining underground cables is far greater than aerial; also that the durability of conduits and cables, in many cases, is mere conjecture, as they have not been used long enough to test their ability to stand the action of acids, and gases, or to test various other requirements, which can only be determined after a sufficient time has elasped.

In cities of less than 200,000 inhabitants compelling companies to place their wires underground will practically prohibit the use of electricity for lights, and leave the inhabitants of these cities to meander through the streets, guided by the sickly rays of the kerosene lamp or the feeble flutter of the gas burner, as no electric lighting company can afford the expense that this would incur, unless they could obtain double the price now paid for lights.

The expense of conduits and underground cables is so heavy that they can only be adopted in a few of the larger cities, thickly settled, and then the electric lighting companies adopting them must be paid a higher price for service, or eventually the company will be bankrupted by the expense and loss entailed. Therefore the taxpayers in any city, who demand that wires shall be placed underground, want to realize the fact that this move means increased cost for lights and larger taxes to pay for the same. From data obtained, it is evident that nearly all the cities could be served with aerial lines for the high tension current in a more acceptable manner and at less expense than with underground conduits, and they could be so arranged as to be perfectly secure and not in any way endanger the public or mar the general appearance of the streets. But as this committee was appointed to investigate underground and not aerial circuits, they have not considered it within their province to recommend a plan for aerial lines.

The discussion which followed brought out descriptions of other systems and the experiences of others. Mr. Hering mentioned that in Paris and London a system was in use in which bare wires were run on glass or porcelain insulators, in concrete conduits covered with flat stones, located either under the sidewalk or the street; in the former case they are only a few inches below the surface. The electric light wires are not allowed, as a rule, in the sewers of Paris, on account of the telegraph and telephone wires. The above system is presumably used at present only for low tension currents, but there appears to be no reason why it should not be equally well applicable for high tension currents. As the sidewalks are, as a rule, private property in our cities and are often vaulted or paved with heavy stones, such conduits would have to be confined to the streets. He also mentioned that a short line of double underground cable had been running in the Frankfort Exhibition with a 20,000 volt alternating current.

Mr. Wilmerding thought the report was a rather pessimistic view of the underground system of distribution. He added: "We think that we have succeeded in Chicago in transmitting currents underground without any trouble. The reason that there are so many failures in places where they are just beginning to do that work is because they do not do it properly. They try to do it at too small an investment. In order to economize in the first cost of construction, people will put in a wire that is too highly insulated. There are systems of conduits in the market which are recommended as being insulated, but I do not take any stock in them. The iron pipe for conduits is just as good as a non-conductor is, except for the fact that it will rust out and become useless in four or five years. The main point to be considered in the conduit is to get a certain strength and elasticity, so as to prevent the conduit from cracking with the action of frost and other causes, and yet be easily repaired. I believe that wood is one of the best substances for conduits we have. In Chicago we have had very satisfactory results with it. We began the work about four years ago, and I had occasion to open the street at one place a short time ago, where this first wood conduit was laid, and I found it in perfect condition, although the weather had been dry for a long while; aside from that, the wood was thoroughly moist; it maintained its moisture all the time. We know that any wood that is kept constantly moist is practically everlasting. Wood has been used for water pipes in towns, and used for many years, and is almost as good when taken out as when laid. The wood, being yielding, bends and takes up any irregularities in use; it maintains its moisture; it affords a very smooth surface for drawing your cables and I think it is a good thing. It has the further advantage of being very cheap.

"In regard to the reliability of the cable, I think I have the right cable, and with sufficient insulation it will carry a reasonable potential for a considerable length of time. I have forty miles at present of a certain cable, with an insulation in thickness of $\frac{5}{32}$ of an inch, which is carrying a potential of five hundred volts on a constant potential motor service of one thousand volts and an alternating service of from twenty-five hundred to three thousand volts in arc lighting service, and which has been in service for over two years, and I have not had a single case of grounding, burn-out, or anything of the kind, on forty miles of conduit. This shows that the conduit system can be maintained with perfect satisfaction if you put it in the right way in the beginning."

Regarding wood for conduits, Mr. Francisco claimed that it depends entirely on the locality. "I can show you a case of wood conduit that has lasted less than nine months; and I can show you other cases, where they have been running for twenty years. It depends on the locality and the soil. In some soils you can lay a conduit and have it work all right; in other soils in a short time you will have nothing but a wood pulp that you can break with your fingers."

In reply to a question whether they have not had trouble with the conduit in Chicago, Mr. Wilmerding replied that he had been told by one of the employés who had charge of the underground circuits of the city plant that they had trouble on one of their underground circuits for about six months, and had not been able to locate it. "Of course, that is a municipal plant." (Laughter)

Mr. Stanley added: "When a high potential continuous current is placed in an underground cable there is a great strain on the insulating material, and this strain is all in one direction. As the result of that continued pressure in one direction, the constitution of the insulator changes, and after six months (in some cases, I believe, in London, in even less time than that) the entire structure of the insulator changes, so that while the cable had a high specific resistance to start off with, it rapidly fell off. In the case of alternating currents this deterioration does not take place. In this case the current reverses rapidly, and the work done by the current passing in one direction is quickly undone by the next wave passing in the opposite direction; the effects thus are neutralized. The effects of the alternating current are more like those of water flowing through a pipe in the following illustration. If we had a long pipe, filled with water, and suddenly turned it on end, the water would rush to the far end, and strike a hard blow, producing a water hammer effect. The longer the cable is underground, and the longer the distance, the greater is this condenser effect; it was so great in the case of the Ferranti main, that it raised the pressure at the far end in London a great many volts higher than at the generator end at Deptford. I think it can be generally stated that insulations made from oil compounds are unfit for a continuous current strain, while they are exceedingly good for alternating currents. In some cases in underground work we found that the cables did not have the capacity they were figured for; the capacity being always reduced. The resistance of the cables for alternating current was considerably higher than it ought to be; in some cases ten per cent. higher, and we were worried a great deal about it. We found that the external resistance in this cable was due mainly to the work that was done in the iron pipe which inclosed the cable, the resistance being principally outside of the wire, and not inside; also that the current in the wire was not evenly distributed, a result which had been predicted long ago by Sir William Thomson. These difficulties were overcome by adopting a certain small standard size of conductors and putting in more cables."

Mr. M. J. Perry thought that the proposition to place the wires underground, in the broad sense, was admitted as practicable by all our best electricians, provided you are prepared to put a sufficient amount of money in it. To be able to put that money in it, it is necessary to offer some inducement to the investor for the use of his funds. "I assume that probably the main line of the Buffalo company is from 25 to 40 per cent. of its capitalization. You must first absolutely shrink that and throw it away, and that is an enormous strain on any corporation. Secondly, you must put in three or four times as much money in the furtherance of your project as you have now invested for distributing purposes; and to secure that investment, you must make it plain to the investor—more plain than you can now do with the isolated instances we have of the workings of underground systems, that he can safely put his money in it, and realize a profit. Up to two years ago at least, the gentlemen from Chicago were not prepared to recommend to investors; they were not, and could not help themselves. I presume they have gone on and worked the thing out; but you cannot get any more American capital on the showing made there; American dollars do not go that way, and they do not grow that way.

"If we could see the books of the Buffalo Electric Light Company, I will warrant you that they would not show that they were making extravagant profits—extorting from this public anything as more than fair and just for the investment and risk of the business. They may possibly be earning a dividend—a fair return on the investment—which a man who invests his money is entitled to; that is only fair and just. This proposition to place wires underground, if carried out and consummated, would necessitate their earning a dividend on at least double their present capital. We will say you have based your prices on a capital stock; that you have an investment which requires that you should earn one hundred dollars per lamp; if the change is made, you will then be obliged to earn two or three hundred dollars per lamp; but you cannot raise your prices. The tendency in prices, in all business transactions, is steadily downward, and you have got to be busily at work to determine and introduce economies that shall take care of that gradual pressure downward; and yet you propose to pay double; and it will be impossible to get higher prices, even though an increased investment should be made. These are the points that must be very seriously considered. This very instance of the Buffalo Electric Lighting Company that is being considered, when you attempt to force them at once to lay their wires underground; it may be that if public pressure is put on strong enough, you can make them do it; it may be that you can send them to bankruptcy; and it may be, that those who come in on the second deal may reap a rich reward. I do not believe, however, that that is the province of any city government, and I do not believe that it is the intention of any intelligent public to do this, if they have been fairly and squarely confronted with the question."

To this Mr. Wilmerding replied: "I do not want to be understood as recommending underground conduits for investors. Mr. Perry misunderstood me about that. When you discuss this matter as a financial question, it assumes a very different aspect, of course As to the question of the practicability of having currents underground, I must say, it is practicable; we know it is. When it comes to the case of investment, it is impossible, with a given rate for service, based on overhead construction, to furnish underground circuits at the same rate. When Mr. Perry assumes that it may cost two or three hundred dollars per lamp for underground construction, he is too low; we cannot do it for less than four or five hundred dollars for a complete plant. Of course, we had a different experience in Chicago from what the Buffalo Company would be subjected to; we never had an overhead construction; never had to throw our overhead construction away. We started in to put wires underground when we began business. After a good many experiments, we managed to make a success of the matter, and our stockholders are not entirely neglected. I do not think it is possible for any company, which is operating by the overhead system, to afford to do the lighting at the same price by the underground; it certainly cannot be done under any circumstances, in a city of small population—two hundred thousand or less; it is practically impossible.

Electric Lighting from a Financial Standpoint.*

BY ERASTUS WIMAN.

It would seem as if in the evolution of progress on this continent that electricity was the flower and fruit. The stupendous change which in the condition of the human race has been possible by development on this side of the sea needed just such a revelation as is possible only in electrical science. A drama of such proportions, on a stage of such magnitude, by a people of such intelligence, illustrating such principles as self-government, such events as a material progress beyond all that the world has ever seen, needed above all things a new force, a new hint from the mysteries of the unknown, a new law of nature as forceful as gravity, as helpful as heat, as widely diffused as air. Electricity thus takes its stand just at its right place in the marvelous procession of events in the human progress towards a higher and nobler life, which has been rendered possible by the discovery of America.

But in contemplating the progress made in the last century, and seeking to discover the influences and forces that have most contributed to the growth of wealth, to the comfort, safety and happiness of the human race, as illustrated on this continent, it may be safely claimed that electricity, even in its early stages, has played a not unimportant part. It would seem as if in a country of such vast areas as is the United States, nothing in the whole category of events would be so highly beneficial as a means of instantaneous communication, and yet this vast boon of instantaneous communication was only possible by electricity.

Incidental to the unequaled usefulness of telegraphy in the marvelous progress of the country, has been its contribution, in a special degree, to the railroad service, which to so great an extent has contributed to material growth, the increase of wealth and to the comfort and happiness of humanity. The use of the railway telegraph has practically doubled the tracks of every single track railroad on this continent, rendering the movement of trains so precisely, so rapidly and so safely that without this facility of instantaneous communication the railroads would not have achieved half which by its aid has been accomplished.

But just as telegraphy had reached its perfect degree of usefulness in general purposes, as in the railroad service, shown by the perfect growth in electrical science, it was supplemented by a still more wonderful faculty of communication in the telephone. My friends, in all the series of wonders which the electrical world has revealed, this telephone is to me the most wonderful. To a layman like myself, who simply wanders along the outer edges of this magical land of discovery, this transmission by the aid of electricity of the human voice in audible and natural tones to great distances is of all things the most marvelous.

But another field of opportunity for the usefulness of electricity for the benefit of mankind has been found in its uses for the creation of light. It is a singular fact that so many ages had passed since the world began, and that only by the slightest degrees was the darkness which falls like a pall upon the earth mitigated. Many can even now remember, especiallly in country places, the tallow dip, the short sixes, the oil and spirit lamp, and the uncertain though mellow rays of the finished wax candle. It is quite within the memory of many men here that petroleum with its wonderful power of illumination was discovered, and all the world has since been blessed, not only by its illuminating power, but by the business skill and sagacity which through the Standard Oil Company has diffused this article so universally, so safely, and so cheaply; illustrating the high benefits of a well managed monopoly as against the universal condemnation of that economic feature of the hour.

With the discovery and development of gas, of course, a vast change took place. But in the sixty years of its development, before it reached its meagre perfection, there was the slowest kind of progress, so that it is only up to within the last half century that artificial illumination became at all general even among great aggregations, like cities and towns.

It remained, however, for electricity, and within our own lifetime, to beget a degree of success in this wonderful work of the creation of light that nothing else had ever yet achieved. It may be doubted if in the history of any science the same rapidity of movement has been made as in the adaptation of this form of energy to the highly useful and beneficial purposes of the creation of light. For instance, remote places adjacent to cities, to which a gas main was an impossibility, have been reached by an electric wire. Neighborhoods have been joined together, localities connected, and property increased in value by rendering communication at night secure and safe as in the day. In the application of the arc light to public works of great importance, like aqueducts, tunnels, and especially to manufacturing, numerous branches of business are susceptible of being carried forward twenty-four hours in the day, which without it would be impossible. Thus is doubled the capacity of many establishments and the earning power of many an investment. In all public places, as in theatres, halls, and in almost all business establishments, where business after the setting of the sun is essential, electricity is already beginning most effectually to supplement daylight, and play a part almost as effective as the sun itself.

It will thus be seen that so far as fulfilling the purposes of its manufacture, electric lighting is a definite and ascertained success. So far as experimentalization is concerned, nothing now remains to convince the public of its safety, of its effectiveness, of its healthfulness, and of its general adaptability to all circumstances.

* A paper read before the Buffalo convention of the National Electric Light Association, Feb. 24, 1892.

Hence, as an article of merchandise, the light furnished by electricity is just as much in demand to-day as wheat or corn, as beef or bread. So that this assemblage of electric light men may congratulate themselves that, notwithstanding many difficulties and obstacles, they have, by the excellence of material, by its reliability and effectiveness, created an article of merchandise of real value, for which there is a strong demand.

It is true that in the creation of this article of merchandise, up to this period, there have been many mistakes. There has been a great waste of money, and if the past had to be lived over again there are not a few who would shape their policy in an entirely different way to achieve the result now reached.

The question of profit remains to be decided in very many localities. I have been favored during the last month or so with an enormous number of letters, in response to a request for information as to the condition of the electric lighting business all over the country. A great deal has been sent me of a confidential nature, and I can only give the general impression which the whole correspondence has made upon my mind. My conclusions are, first, that there is an enormous demand, only as yet partially developed and partially met, for electric lighting; second, that the public have been led to believe that it can be created for very little money; third, that in competition with gas an insufficient price has been asked for a light infinitely more brilliant, infinitely greater in candle power, far more healthy, and, as a rule, far more safe; fourth, that at the start of many electrical plants the most meagre and insufficient foundations were laid for a business requiring the utmost precision and the most perfect material.

It is these conditions, coupled with the rapidity with which inventions have followed, one upon another, the constant reduction in the price of electrical machinery, the rapid growth of electrical appliances and the radical changes and methods, which in six months would appear to be old in the history of a business which was so new and making such tremendous strides as make it exceedingly difficult to maintain the expenditure on capital account within the original limit of corporations.

Looking back upon the past, it is easy enough to account for the difficulties, obstacles and want of profit in many establishments, but if there is one thing more than another that has made the progress toward profit a difficult one, it is the mistaken apprehension of the public, that electricity can be got for nothing. There is something so mysterious and occult, something so magical about electricity, that the impression has got abroad that it is only necessary to press the button, and with the least exercise of skill, labor or expenditure, the miracle is produced. The attempt to compete with poor gas, at a low price, with infinitely less illuminative power was, of course, a necessity. But the public estimation of electricity has never yet reached the standard which it should have done. The slow introduction of the current into private houses is perhaps the best illustration of this condition. Even to-day, in some cities, it is thought that the arc light can be had for 15 cents a night and the incandescent light for a mere song; $15 a year is slightly over a quarter of a cent an hour, yet for this, for 10 to 12 hours, a beautiful bulb of incandescence is expected at every street corner and in every remote suburb for almost less than it would ordinarily cost to burn a wax candle.

The public estimation of the cost of electric lighting has been allowed to prevail to an extent destructive of profit. There has been an hallucination prevalent that there was something miraculous about the production of electricity. The cost of coal, labor and machinery has not entered into the calculation of either the ordinary city official or the private customer. The expectation that something would be produced for nothing, which inheres in the human mind as to the possibility of invention, has attached itself to electricity more than to any other element in the supply of human wants. The consequence is, that in making new contracts, even to-day, there is the strongest disposition to get the prices down, not to what the article can be produced and paid for, but for the least possible amount, irrespective of profit, and equally irrespective of efficiency. There is a true and false economy, and that is the falsest kind of economy that expects a public service at less than the cost of its output and a fair profit.

Having in the process of time developed a large demand for light, evidences of which are seen on every hand; having at the same time gone through a most unusual experience in not only creating that demand, but in the production of the article for its supply, a review is in order as to the present position of electrical securities and the prospect of profit. It may as well be admitted that there has been a serious and costly struggle, and that, taken as a whole, the results in the shape of a total profit on the total investment in electric lighting is not to be seen in the shape of dividends. There are, however, happily, exceptions to this general statement, and in the returns sent to me from all parts of the country there are a considerable number of companies whose career has shown that in electric lighting there resides the potentialities of a profit equal to that of any legitimate enterprise. The successful companies illustrate what it is possible to do, and though they may not be numerous in comparison with others whose record for profit is small or who report a loss, yet that money can be made continuously and rapidly out of electric lighting is clearly demonstrated. In order to cite an example of steady growth in revenue, and also to show the corresponding ratio of expense, I append the figures for seven years, from one of the most successful companies in the East, whose management has been characterized by the highest ability, and whose location and name it would hardly be proper to disclose. The figures are authentic, and show a record of which any man might be proud.

EARNINGS OF AN ELECTRIC LIGHT COMPANY.

For 1885—Receipts		$30,768.70
	Expenses	24,901.54
	Net earnings	$5,867.16
For 1886—Receipts		$47,613.76
	Expenses	34,700.83
	Net earnings	$12,912.93
For 1887—Receipts		$57,750.71
	Expenses	34,691.85
	Net earnings	$23,058.86
For 1888—Receipts		$75,734.14
	Expenses	46,235.83
	Net earnings	$29,498.31
For 1889—Receipts		$135,254.08
	Expenses	94,178.69
	Net earnings	$41,075.39
For 1890—Receipts		$199,195.72
	Expenses	150,195.48
	Net earnings	$49,000.24
For 1891—Receipts		$247,679.88
	Expenses	187,092.77
	Net earnings	$60,587.11

The company commenced to pay dividends Jan. 1, 1887, at the rate of 8 per cent., payable in quarterly dividends of 2 per cent., and have continued the same up to date.

Before closing the books Dec. 31, 1891, we charged off from the earnings of 1891, for depreciation, $10,000 from the steam plant, and $30,000 from the electric plant. On Jan. 1, 1892, captital stock, $800,000; surplus, $90,000.

The above figures speak for themselves, and in the progress shown in receipts and profits there is contained a hopeful sign for many another company whose career up to this time has yielded an inadequate return. Indeed, to present a totally different picture, here is an extract from the letter of an esteemed Western friend that shows the ruins of a senseless competitive struggle and the folly of low prices:

"I am the president and manager of five electrical light companies in this city, but *three* of which have actually survived financial pressure and bankruptcy. One of these three, with a capital of $150,000, fell behind nearly $100,000 in seven years, and last year the stockholders voluntarily came up with an assessment of $60,000 to save it from bankruptcy. Another, working under the strictest economy, is but barely able to meet operating expenses. Still the other, a foundling of the gas company, is, under exceptionally favorable conditions, and paying no salary to its executive officer, making a little money; after 18 months' operation, it last month declared a dividend of 3 per cent."

With such an experience it is no wonder that the gentleman writes as follows:

"I am aware that books can be kept so as to show an earning, but this is in many cases at the expense of a constantly depreciating capital investment."

These two extremes of success and failure tell the whole story of electric lighting in the past seven years. The companies, that have succeeded have done so under favorable circumstances, with a freedom from ruinous competition, exacting good prices, and above all other requisites, with good management. If there is any department in human activity where brains and tact are required to a greater degree than any other, it is in the administration of an electric lighting plant. This is evident, not only because there was a great lack of experience and knowledge of a business that was in the production of an article that was in a certain sense mysterious and unknown, but because there has been an amount of misapprehension as to its cost on the one hand and its value on the other hardly ever experienced regarding any article of merchandise.

Some attempt has already been made to account for a misunderstanding as to the cost of electric lighting, but it is proper to allude to the folly which has prevailed in selling it for less than cost. The insane competition with each other in localities where one company was needed and more than one was ruinous is well nigh passed, but there remains the competition with gas companies and the effort made to constantly lower the standard of electricity to that of gas. It was perhaps essential that in the early history of the effort to use electricity as an illuminant, it was necessary to get down to the standard of the fumes of coal, and in order to show the superiority of one over the other, to yield for a time in the matter of profit. But so rapid has been the growth in the use of electricity, so immeasurably superior is the current to the fume, in health, in brilliancy, in beauty and attractiveness, that the time seems near when electricity can claim the rightful place, and demand the price just so much higher as it is an illuminant just so much better. An advance in price commensurate with the superiority in the article produced would add largely to the earning power of electric lighting companies, and it is time it was contemplated and acted upon.

One misfortune has been in electric lighting that a large investment has been available for only a small portion of the time. All day long, when other works by rental or by active employment were earning money, electric light plants have been compelled to stand idle. Even gas companies spend the whole day making gas, accumulating it in their reservoirs for distribution during the night. Electric light plants, however, are compelled to manufacture and distribute at one and the same time. A change, however, impends in which these costly plants and lines of copper can be used every hour in the twenty-four. The development of the facility for the transmission of electricity for power has, however, within the last two years, made rapid progress. The introduction into small manufactories of the current to be used constantly or intermittently has, in many localities, become very general. Already in the correspondence sent to me there are quite a few indications illustrating how advantageously the electric light plants can be used during the day for the purpose of power. In cities where manufacturing is going forward there are hundreds of establishments in which the power required can be furnished from a central station. In the working of sewing machines, both in large establishments and in private houses, in the running of small lathes, hoisting machinery, elevators, and even large trip-hammers, in the circulation of air in sick chambers, in even rocking the cradle, the usefulness of electricity is becoming apparent, so that a new era opens for the usefulness of the plant, poles, wire and franchises during the day.

In this respect, with this in view, the whole electrical community are watching with intense interest the possibility of the development in this city of Buffalo electrical transmission arising out of the successful effort which is now being made to harness the power hitherto latent in the Niagara River. The boldness of the proposal, the extent and character of the enterprise which is now nearing completion in this effort, the pluck and push in the work, challenges alike the attention of the engineering and commercial world. The relation of this enormous power of nature to the transmission of electricity is the most important consideration which now occupies the thoughts of those most interested. The success which has attended the three-phrase current from Lauffen to Frankfort in the transmission of power 112 miles, without material loss, comes just at the right moment to make it seem possible that the enormous potentialities in the forces of Niagara can be made to reach a degree of usefulness never dreamt of in the past and hardly realized in the wonderful present. It seems fortunate, therefore, that the convention which is here assembled should, as it were, be in the presence of the most stupendous event possible in the history of the science of electricity. In the development of the next few years will be found ample food for thought and effort, out of which may grow a relief for electric lighting plants of the greatest possible consequence. If in the city of Buffalo and from the Niagara River there can be transmitted power in such enormous proportions as are now contemplated, subdivided and reduced, so that into every factory and almost into every house the force and energy can be controlled and operated, there is latent in every central station the possibilities that may come to every town in the country and to all the electric light plants now lying idle during the day, an imitation in modified form of the power that of all forces in the world Niagara is the best example.

The success which has in so brief a period attended the application of electricity to traction, and the enormous numbers now moved throughout the country by electrical roads, make it reasonably sure that before very long steam roads in crowded localities will be worked by electric energy. Already the great Illinois Central, having so large a portion of its tracks in the city of Chicago, have in contemplation this marked change. The Wisconsin Central are also favorably considering it. Possibly it is a little too soon to anticipate this change, but that it is coming there can be no question.

In New York City, in Boston, in Brooklyn and in such suburbs as Staten Island, there is no reason why electricity should not be substituted for steam. Steam locomotives, built to carry their coal about, and to employ an engineer and fireman for each 500 h. p. generated, cannot compete with the great compound, condensing stationary engine, whose forceful power can be extended by a delicate wire distances of twenty-five miles and under.

It is only a question of time when numerous roads, having a limited or circumscribed area, will consider the propriety of changing from steam to electricity, and, with that in view, electric lighting plants now being constructed should contemplate a sufficient enlargement so as to be able to sell power to nearby steam roads. It would indeed be a revolution of enormous proportions if, from these central stations, a force sufficient could be furnished for operating suburban roads, whether steam or electrical.

In this connection it is impossible to contemplate the extension of the lighting and railway systems dependent on electricity without alluding to the consolidation now in progress between the two great electrical manufacturing organizations that, more than all others, have promoted these most important interests. After a somewhat careful study of the question of competition, of consolidation and the establishment of a strong and well managed single concern, as compared with weak and numerous rival undertakings, my deliberate conviction is that all the dangers of monopoly, all the possibly increased charges for supplies and other fancied ills, are as nothing as compared with the waste of unbridled competition. In the consolidation of the Edison and Thomson-Houston companies a new and important area opens for all interests concerned in electricity. With such experience, such skill, such business sagacity and such inventive faculty as has been developed within these companies, now that they are united in one nothing but good can result, not only to the companies themselves, but to the electrical community at large.

In the telegraph business a larger capitalization exists, in proportion to the cost of the material, with a capacity to earn a dividend upon the amount, than in any other department; while in the telephone, and more recently in the electrical railways, the amount realized is in excess of that from any other investment. It is true that in electric lighting a universal success has not been achieved, but beyond all question a great and useful purpose is being served in the creation of light, for which a profitable and steady demand exists, and which can be supplied through the experience and the improvements attained, as the result of the operations thus far.

The future is full of promise for these undertakings, especially in the value of the franchises, the ability to furnish power, in their combination with the gas industries of the country, which must be only a question of time, and in their ability to promote and to assist in the application of electricity to street railway enterprises. The whole subject of electricity, as applied to business, is full of the deepest interest, and no one who feels grateful for having been born in this age, and enjoying all the advantages of the most advanced civilization, can fail to recognize in this wonderful force the advantageous contributions toward the good of mankind, and hold in high estimation the men who, in so short a period, have so rapidly promoted its introduction and high degree of usefulness.

The Convention Banquet.

The scene on Thursday night in the great Board room of the Merchants' Exchange when the wide doors were thrown open was a magnificent one.

The head table was set across the end of the room and raised to a level with the desk. Half a dozen tables ran the full length of the hall. All were most handsomely set.

In the seat of honor was Mayor Bishop. At his right was Mr. Huntley, the retiring president; at his left was Mr. James I. Ayer, of St. Louis, the new president. Next to Mr. Huntley was Prof. Elihu Thomson, of Boston; Prof. Elisha Gray, of Chicago; John N. Scatcherd, of Buffalo. The famous Marshall P. Wilder and all those on the toast list also had seats at the head table.

The menu card was a work of art. On the back cover was a humorous illustration picturing electric light stockholders in a hole and kept there by injunctions, vetoes, resolutions and various other forces.

The tables were set for 400, and very nearly that number was present. About half the company were delegates to the electric light convention and the others were Buffalo people.

After justice had been done to the dinner, Mr. Huntley arose, rapped for order and in a few well-chosen words introduced Mr. John N. Scatcherd as toast-master. Mr. Scatcherd performed the duties of his difficult position with grace and wit. He bid the guests a hearty welcome and pleasantly introduced Mayor Bishop to speak in reply to the toast of "The City of Buffalo."

The Hon. E. A. Armstrong, of New Jersey, replied to the toast, "The National Electric Light Association." He made a witty speech, praised Buffalo and her hospitality and said that when the place for holding the next convention was being fixed many of the delegates were in favor of stopping right here until the next meeting.

Passing on to serious consideration of his subject, the speaker said that in electric inventions and enterprises no one dare say where human ingenuity will stop. He asked the citizens of Buffalo to foster and encourage great enterprises and help along the march of progress. He referred to Prof. Thomson and Prof. Gray as wonder workers in electrical matter and both names were vigorously applauded.

Richard K. Noye of Buffalo replied to "Buffalo Manufacturers." He spoke of the growth of Buffalo in a manufacturing way, of the activity which, beginning in 1880, followed a long period of stagnation, and of the continuance of that activity ever since.

"Municipal Lighting" was replied to by C. H. Wilmerding, of Chicago. Among other things he said that 50 cents a light per night was a fair and reasonable price for electric light in Chicago and created amusement by saying that some municipalities demanded electric lights at sperm oil prices.

John G. Milburn and "Buffalo Electricity" were coupled by the toastmaster. Referring to the Niagara tunnel and the hopes built upon it, Mr. Milburn said it would make Buffalo the manufacturing centre of the new world, as we would have the grandest power of the world at minimum cost.

Mr. Ayer, the new president, was now introduced and made a few pleasant remarks. He was loudly cheered and the company sang "He's a Jolly Good Fellow."

"The Electrical Press" was responded to by T. Comerford Martin of the *Electrical Engineer*, New York.

"I have been told," said Charles F. Kingsley, replying to "The Buffalo Press," "that the test of a transformer is the

load that it can carry," and there he paused. Prof. Elihu Thomson was loudly cheered when he got upon his feet to reply to the toast of "Electricity."

William Stanley, Jr., of Pittsfield, jumped up when Prof. Thomson sat down and proposed three cheers for "Prof. Thomson, the foremost electrician of the age." They were given with a will. Mr. A. J. Corriveau responded in place of Prof. Bovey, and in addition remarks were made by the ex-President, Mr. Huntley; the President-elect, Mr. Ayer; Prof. Gray and Geo. Urban.

Convention Notes.

The complete list of those in attendance at the convention, as well as a full account of the exhibits made by private individuals and firms was given in our Convention Bulletin, a copy of which was mailed to our subscribers from THE ELECTRICAL WORLD headquarters at Buffalo. It is therefore unnecessary to repeat these in the regular issue of the paper.

The hospitality of the International Okonite Company was enjoyed by all those who came under its influence. On Tuesday and Wednesday evenings the company's parlors were the resort of many members and guests, a rare treat being furnished by the inimitable story telling of Mr. Marshall P. Wilder. This was a new feature of the N. E. L. A. conventions, and one that proved a delightful innovation to both ladies and gentlemen.

Col. J. H. Shay, of the Charles Munson Belting Company, Chicago, greeted many old friends at the convention. The Colonel has just returned from the far West, and reports a large number of unusually large orders from electric light and street railway companies.

The Crescent Insulated Wire and Cable Company, of Trenton. N. J., was represented by Mr. Richard K. Whitehead, who reports an increasing demand for their products.

The Simplex Electric Company of Boston was represented by Mr. J. H. Mason, general manager. Although not soliciting orders, it was pleasant to note that of those placed the Simplex secured its share. Mr. Mason reports a gratifying spring trade with a large increase in the electric railway department.

Mr. J. C. Pierrez, of the Columbia Rubber Works, selling agent for B. F. Goodrich and the Goodrich Rubber Company, always makes his convention trips profitable, and this year, as usual, returned with a large number of orders.

The Ward arc lamp people never have to return any samples they carry along with them. Their search light and "Ward lamp" was purchased by the Iroquois Hotel, and Matthews, Northrop & Co. were glad to secure their photo-engraving lamp.

Mr. Wm. Stanley, Jr., of the Stanley Laboratory, Pittsfield, Mass., attracted general attention by his bright, intelligent discussion of difficult points brought out through the medium of the papers read. Mr. Stanley is to-day in the foremost rank of leading electricians.

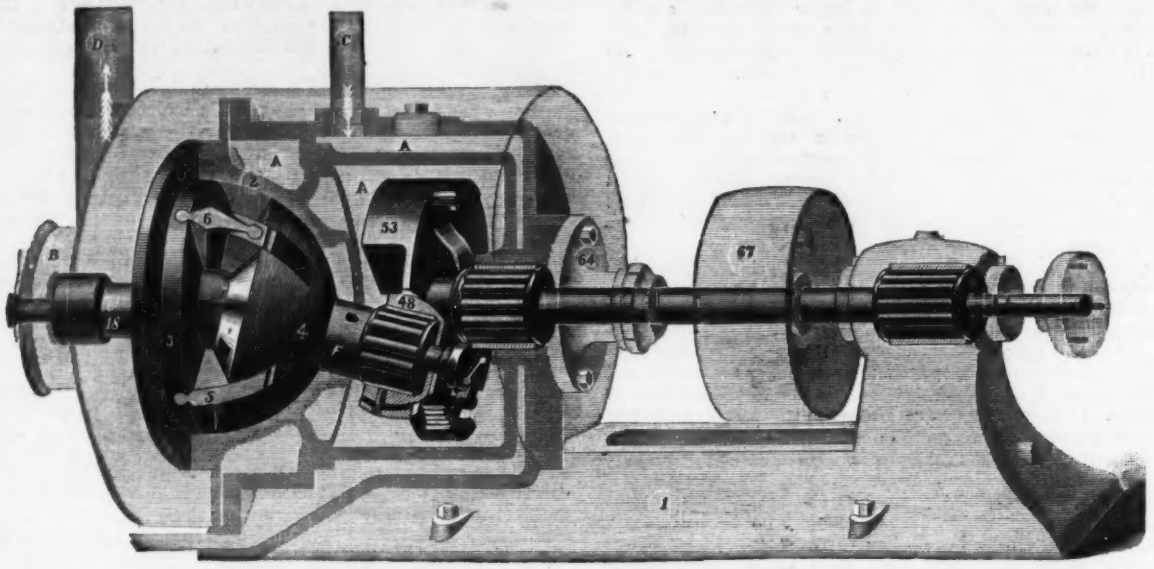
Mr. Henry Hine, the energetic head of the business department of the Stanley Electrical Manufacturing Company, while at the convention expressed himself as well pleased with the past year's business of his company, and said the future outlook was one of great promise, their goods being well received and orders constantly increasing.

The Manhattan Electrical Supply Company, of 36 Cortlandt street, New York, has secured the services of Mr. Geo. Woolcock, who for the past thirty years has been in the speaking tube business. The company hereafter will be manufacturers of speaking tubes on an extensive scale. This company continues to receive large orders for Mesco dry battery, and has notified all customers that it will defend without cost to purchasers any infringement suit that may be brought against them, as it does not propose to let its customers be imposed upon by misleading or threatening circulars.

The Electrical Engineering and Supply Company, of Syracuse, N. Y., was represented by F. A. Leonard, J. L. Hynes, J. D. McIntire and H. J. Gorke. Their exhibit was a most complete one and consisted of cut-outs, rosettes, sockets, fixtures, branch blocks; a new lock switch especially adapted for public institutions where it is necessary that only proper persons should turn on and off the current; a new wire porcelain tube which can be driven through plastering with a mallet and which has been adopted by the underwriters; a new porcelain covered switch which is keyless and especially adapted for neat work, and a handsome line of switches from 30 to 1,000 ampères and which are beautifully mounted on marbleized slate and pure marble. By an ingenious arrangement all wires connected with these switches are concealed and not shown at all on the switchboard. By referring to their announcement, which appears on another page of this issue, the reader may gain an idea of some of the specialties manufactured by this company.

An Unusual Type of Steam Engine.

To free the steam engine from the necessity of reciprocating parts has been the effort of inventors for the last half century. The rotary engine has been a favorite type, which, perhaps, has reached its highest development in the steam turbine. Various compromises between the turbine pattern and cylinder engine have been devised, such, for example, as the Colt disc engine, which has been in considerable use for light power. A very interesting specimen of a compromise between the rotary engine, built on the plan of a water wheel or rotary pump, and the ordinary forms, which require the use of a cylinder, is the American high speed engine, which is illustrated herewith. Its salient peculiarity is the form and function of the piston, which is best described as a wabbling, spherical segment. It is, in fact, a spherical segment fitting in a seat that forms a spherical surface, and the space between it and the back of what may be termed the cylinder is divided by valves sliding in slots in the piston, so that the successive admission of steam to these different departments gives the piston a rotary wabbling movement, which is communicated by a universal joint to a crank disc.



AMERICAN HIGH SPEED ENGINE.—INTERIOR VIEW.

Fig. 1 gives a very excellent idea of the peculiarities of the machine. The piston, 4, which is a segment of a sphere, fits into the spherical end of the steam cylinder. There are four partition blades, 5 and 6, and the corresponding ones diametrically opposite, which slide in slots in the piston and divide the cylinder into four segments. To these steam is admitted in succession and successively exhausted, thus giving the requisite rotary motion. The projection from the front of the piston drives the crank disc, 53, by means of a cylinder bearing joint. As steam is admitted to the compartments containing the crank disc the pressure of the piston on its spherical seat is reduced to a very small amount. The steam chest, *A*, is ring-shaped, surrounding the seat of the piston.

The governor is on the back of the crank disc and is of the ordinary automatic cut-off type, varying the power by varying the cut-off. The speed for which the ordinary sizes of this engine are designed is about 1,000 revolutions per minute, and as in each revolution there are four separate chances to vary the cut-off, the regulation of speed is said to be excellent.

The engine is undoubtedly very economical of floor space, and lends itself very readily to direct coupling to ordinary forms of dynamos.

Fig. 2 shows the engine as connected directly to an Edison machine. Arrangements are made to work this type of engine compound, in which case two cylinders are put on opposite sides of the pulley, or machine to be driven, and the steam used in one is exhausted into the other.

Roller bearings are adopted throughout for the purpose of reducing friction as far as possible. For steam launches and the like reversing gear is supplied, and the whole apparatus can be placed low down in line with the shaft.

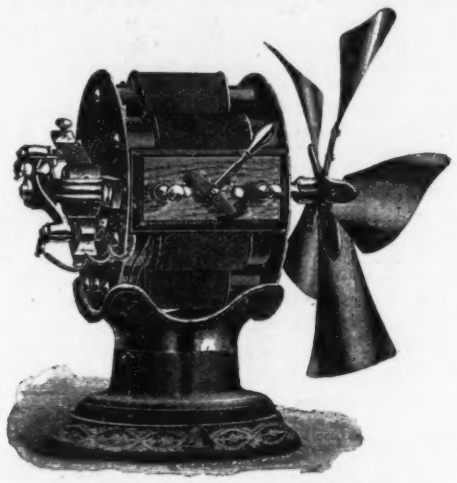
A high economy is claimed on the ground of very high speed. At all events the machine is an interesting one on account of the exceedingly peculiar nature of the mechanical motion, and the ingenuity with which the difficulties of bearings, governing and the like have been attacked.

The engine was designed by Mr. E. S. Smith, and is manufactured by the American High Speed Engine Company, of Bound Brook, N. J.

The Bijou Electric Motor.

In the accompanying illustration is shown the type of motor called the Bijou, manufactured by the Consolidated Motor Company, of Boston. These motors are built in two styles, one being intended for battery currents and the other for the use of constant potential lighting circuits.

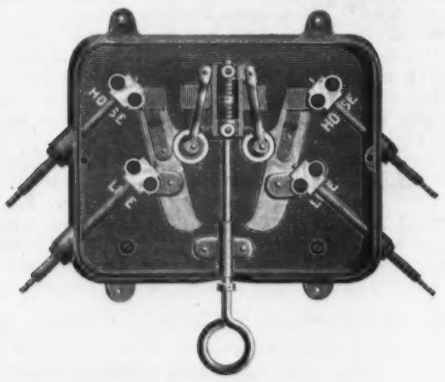
The motor is simple in construction and it is claimed that it is very economical in the use of currents. A further advantage possessed by this machine is that all its parts are interchangeable, so that any one may be ordered and attached at any time should any part become broken or injured in any way.



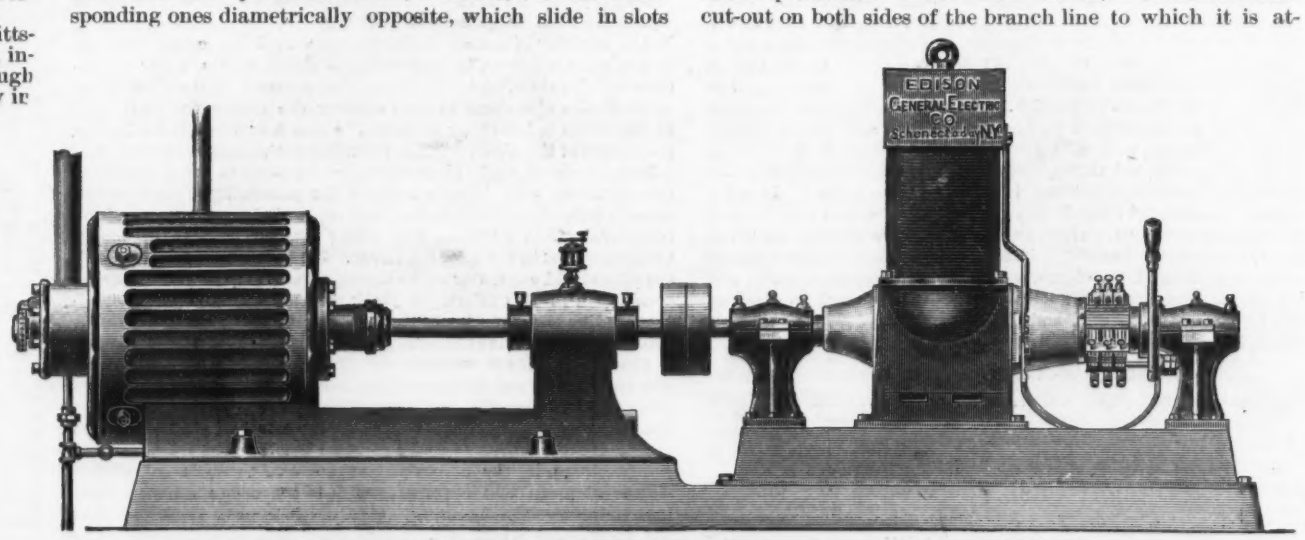
THE BIJOU ELECTRIC MOTOR.

An Arc Cut-Out Box.

The illustration shows the new arc cut-out box which has been adopted by the Thomson-Houston Electric Company, as superior, it is stated, to any yet placed upon the market. This switch will displace the older and more complicated forms previously used, being simpler in construction, neater in appearance, and having fewer wearing parts. The action is instantaneous and automatic, with no possibility of a stop between "make" and "break," and is an absolute cut-out on both sides of the branch line to which it is attached. It is inclosed in an iron box cast in one piece, making it perfectly waterproof, and is fitted with an iron cover containing a square slot, through which is seen an enamel tell-tale plate, clearly showing whether the current is on or off. It is said to be absolutely fire-proof and perfectly insulated, the switch parts being mounted on a slate base, which is securely fastened within the iron frame.



ARC LIGHT CUT-OUT.



AMERICAN HIGH SPEED ENGINE COUPLED TO AN EDISON DYNAMO.

Fuel Economy in Steam Boilers.

It is well known to every one acquainted with the practical working of steam boilers that in all cases there is a large amount of surplus heat escaping up the chimney, which ought not to go to waste, but should be used in heating the feed water for the boilers. The raising of the

temperature of the feed water not only saves a large quantity of fuel, but it also clears the water of a great proportion of its impurities which would render the heating surface of the boilers coated and inefficient, and also saves repairs due to strains of inequal expansion, which are avoided by the water entering the boilers at a high and equable temperature.

Many devices in the shape of coils of wrought iron, brass and copper have been tried from time to time in order to obtain this much desired object, but have proved impracticable from various causes, the chief of these being the destuction of the tubes caused by the corrosive influences of the flue gases and the difficulty of keeping the pipes clean from incrustation and deposits caused by impurities in the water; and outside by soot and dust, which naturally collect on the pipes. These objections are fully met in every detail, it is claimed, by the Green economizer, as shown in the illustration. It is made entirely of cast iron, the only practical material which, it is stated, can successfully resist the corrosive influences of the flue gases. It is composed of pipes about four inches in diameter and nine feet in length, joined in sections (of various widths as required) by heaters or top and bottom boxes, these again being connected with top and bottom branch pipes running lengthways on opposite sides outside the brick work of the flue which incloses the economizer.

The apparatus is evidently made in the most substantial manner, the joints being all iron to iron pressed together by hydraulic machinery, and tested to 350 pounds per inch before leaving the works.

The waste gases are led to the apparatus by the ordinary flue from the boilers to the chimney.

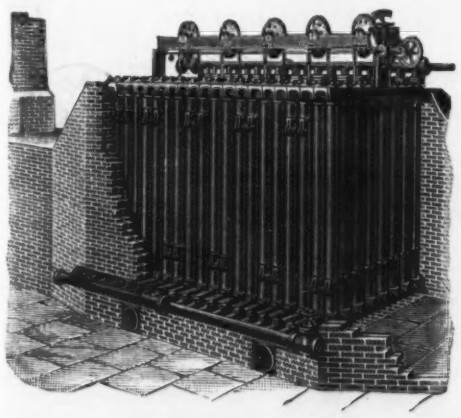
The feed water is forced by the pump or injector into the economizer at the end next the chimney, and leaves it at a temperature varying according to condition from 240 degrees to 330 degrees Fahr.

The pipes are kept clean outside by automatic scrapers, which travel continuously up and down the pipes at a slow rate of speed, and operated by a reversing gear specially designed for the purpose.

The economizer is fitted with a safety and blow off valve similar to a boiler, and each pipe and cross section being fitted with a cap; it is easily accessible from the outside of the brickwork for internal cleansing.

We understand that the economizer has been applied to over 150,000 steam boilers, and many of the largest steam plants in the United States are using it, notably the American Sugar Trust, who say they "would not put down steam boilers without it," thus confirming the opinion of the most noted European engineers who, it is stated rarely draw a plan for a boiler plant without arranging for this apparatus, in many cases putting it down to the hoisting engines of coal pits, the advantage in the latter case being chiefly the purification of the water, and increased efficiency and length of life of the boilers.

It not only feeds the boilers at a high temperature, but also supplies a large surplus of hot water for other purposes if required, and makes a large saving of fuel, averaging from 15 to 25 per cent., and increases the evaporative power of the boilers to which it is applied when more steam is required. After importing this specialty for many years Messrs. Edward Green & Son, Limited, of 172 Broadway, New York, have established works at Matteawan, N. Y., where they have a plant complete in all details for the exclusive manufacture of the economizer, and are prepared to turn out a machine combining the highest class of workmanship and efficiency.

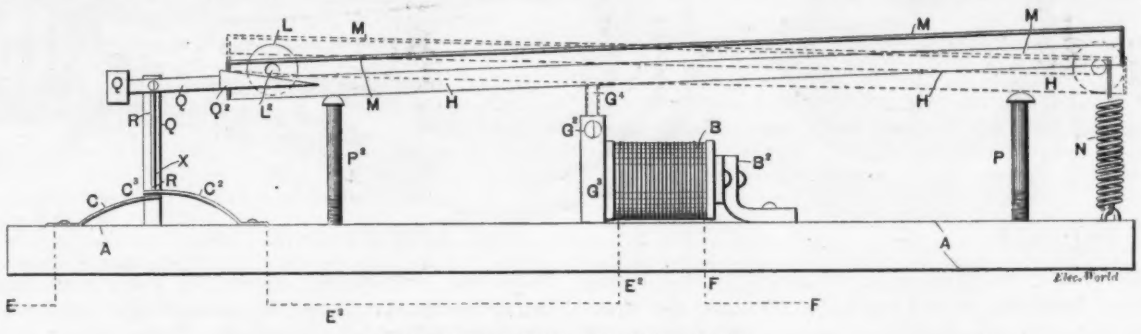


GREEN ECONOMIZER.

The Clough Battery Cut-Out.

It is only those who are accustomed to the enjoyment of the advantages of electric gas lighting that really appreciate how exasperating it is to have to descend to the use of matches throughout a building when for any reason the gas fails to light electrically. The most common cause of this failure is the running down of the gas lighting battery due to accidental establishment of a permanent ground. There are so many causes which may produce this trouble that even the most carefully installed systems are not free from it.

Some devices have been placed upon the market for automatically preventing this too frequent occurrence by effecting the disconnection of the battery when the ground takes place. The arrangement devised by Mr. A. L. Clough, of Boston, seems to offer certain advantages. In this there is provided a straight beam, grooved on its upper surface, and held on a bar axis so as to be capable of motion in a vertical plane, so that its direction of inclination can be reversed by tipping it through its horizontal position. It is held in one position by a spring, and capable of being slanted in the opposite direction by the armature of an electromagnet, which is included in the main gas lighting circuit.



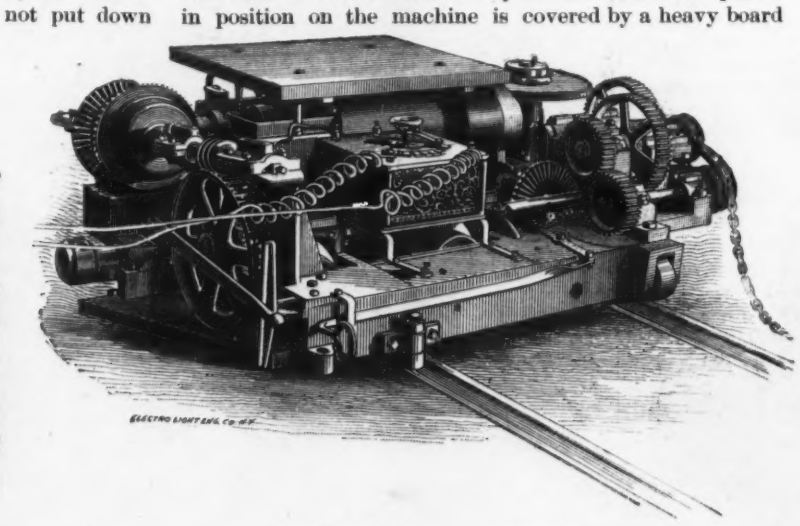
CLOUGH BATTERY CUT OUT.

In the groove of the beam runs a small metallic roller. Near the end of the beam, which is normally held up by the spring, is a fork which, when depressed, actuates a detent, allowing contact springs to part and open the lighting circuit.

The action of the device is quite simple. While a momentary closure of the circuit occasioned by the lighting of a burner hardly causes the magnet to attract its armature and tip the beam, a closure for several seconds does cause the beam to tip and allows the little roller to traverse a portion of its grooved path, but it immediately returns to its original position. This arrangement is very simple, cheap and sensitive, and can readily be made sectional, so that only the particular circuit on which the trouble takes place will be opened by its operation.

Electric Coal Cutter.

The accompanying cut illustrates a coal cutter of the undercutting type driven by a 15 h. p. C. & C. electric motor of special design. It is in operation in the Mead Run mine in the State of Pennsylvania. The motor placed in position on the machine is covered by a heavy board which serves to protect it from possible injury from any heavy object falling upon it. The starting box is also placed on the machine in a convenient position, as can be seen from the illustration. The armature shaft carries a beveled pinion at each end, and by a mechanical device this can be made to operate the endless chain to which the coal cutting knives are attached and which revolves about the arm, and also to operate the feed chain, which is made fast at one end, so that the machine can be moved forward at any desired speed or allowed to remain stationary if the hardness of the coal so requires. The potential of the electric motor being low, 220 volts, there is no danger to be feared, it is stated, from coming in contact with the wires. The knives used for cutting are of the greatest durability and when dulled can readily be replaced by a new set. By using this style of machine the necessity and inconvenience of moving by hand in a low room is avoided and the track on which it travels is such that it can be easily laid or moved as desired. Two men are sufficient to operate the cutter,



ELECTRIC COAL CUTTER.

one regulating the speed of the gears and the other attending to the moving of the machine. The Thomson Houston Electric Company has found this machine so successful, it is said, in mines where an undercutting machine can be used to advantage, that it has made an arrangement for its adoption, and it is expected that several mining machinery manufacturers will do the same.

Arc Lamp Support.

The hanging of electric arc lamps in places where there is liability of accident from falling lamps causing injury to persons, as well as to property, has brought out a device known as Fletcher's "Sure Grip" lamp support, an illustration of which is given herewith. By means of this device it is claimed that there is no extra strain or pull on the rope, and all weight is removed from every part of the rope as soon as the lamp is in position, and it is impossible to wear the cable by swinging and chafing. It is regarded as a very ingenious device, and, it is said, is giving good satisfaction wherever in use. The Electrical Supply Company, Randolph street and Michigan avenue, Chicago, are wholesale agents for these supports.

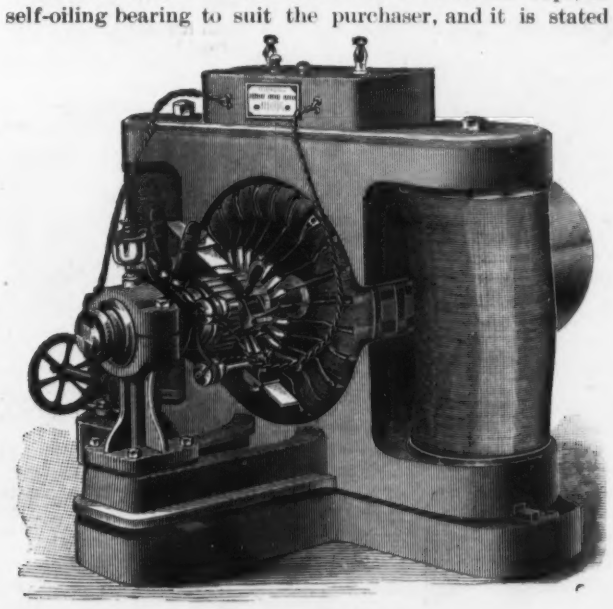
LAMP HANGER.

A New Arc Generator.

The arc generator built by the Duplex Electric Company, Limited, of Corry, Pa., possesses many of the general characteristics of the incandescent generators manufactured by this company, as will be seen by the illustration, which is of a 1,350 volt dynamo. It is of good design and simple in construction, and is said to be a cool running, highly efficient series machine. It has an armature of the closed coil type with 16 to 34 coils according to size, made so that any coil may be removed without interfering with the rest. The armature core is of the Gramme ring type, is constructed with special reference to perfect ventilation, and to prevent short circuiting. The commutator is of hardened copper, thoroughly insulated with mica; in fact, mica and wood are the principal insulators used throughout the generators. The armature shaft is of Bessemer steel, and runs in carefully fitted phosphor bronze bushed boxes swiveled to insure alignment.

These machines are made with wide fitted oil cups, or self-oiling bearing to suit the purchaser, and it is stated that a hot bearing on these machines is unknown where ordinary care is used. There are no rheostats or resistance coils used on either the arc dynamo or on the incandescent generator manufactured by this company, the regulation being accomplished on the arc dynamo by changing the position of the brushes on the commutator. When so ordered it is fitted with a simply constructed automatic regulator, which is sensitive to the slightest change of load, and acts quickly and quietly by changing the position of the brushes.

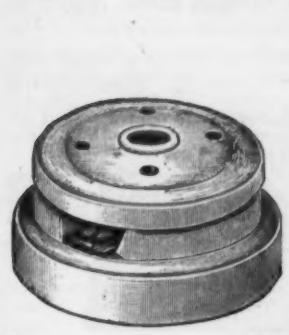
This generator was designed by Mr. W. E. Cady, the electrician of the company, who has had years of experience with nearly all other makes of apparatus, as well as designing several different dynamos, but it is said that this is one of his latest and most perfect designs and overcomes many objectionable points common to dynamos for arc lighting. Every generator is thoroughly tested to its fullest load before leaving the factory. They are made in any size, from 5 to 50 lights in 1,200 and 2,000 c. p. type.

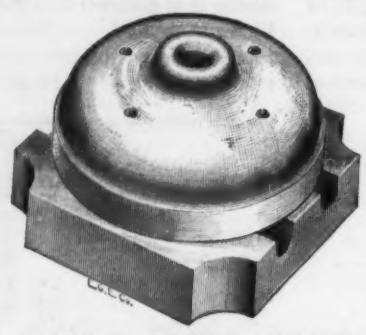


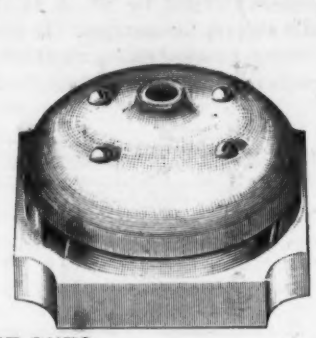
DUPLEX DYNAMO.

New Ceiling Cut-Outs.

The growth of the practical application of electricity and its adaptation to popular use has created an immense demand for cheap appliances which are required to be at the same time thoroughly efficient in their functions. As a consequence, there has been called into existence a large number of these appliances, among which ceiling cut-outs are not the least numerous. Recognizing the possibility of the increase in demand, the Edison General Electric Company invented and patented some years ago a ceiling cut-out embodying most of the fundamental principles underlying all cut-outs devised for a similar purpose. Recently the old form of single pole pendent cut-out was superseded by a double pole cut-out of a novel shape, especially devised for cleat work and possessing additional recommendations and advantages. We show in the illustrations the several forms of these cut-outs.







FIGS. 1, 2 AND 3.—EDISON CEILING CUT-OUTS.

Fig. 1 is a cut-out in the manufacture of which the Edison company, recognizing the necessity of cheapness, aimed to reduce the cost by the adoption of new principles of manufacture, so that a cheap article could be turned out without depreciation of quality. This was followed shortly afterward by two new double pole cut-outs, one for molded work the other for concealed work shown in Figs. 2 and 3. These are of special design and of superior workmanship to that mentioned above, their interior construction, however, being similar. The contact pieces in the porcelain base are flat, and are provided at their terminals with small indentations which serve to catch and retain the bent contact pieces in the cover, and make a perfect contact. Two safety fuses protect the appliance. The cut-outs are made of the best hard, white, non-absorptive porcelain, and when decorated form a valuable adjunct to the available stock of the present day interior decorator. The Edison company will shortly be ready to supply decorated ceiling cut-outs to suit any and all requirements. The designs already selected are varied and artistic. The establishment of a porcelain factory under their immediate supervision in their own works at Schenectady has enabled them to bring these cut-outs to that high state of perfection already attained by manufacturers of the most advanced porcelain for electrical purposes in England, where the development of porcelain for electrical uses has been greatest.

The use of ceiling pendent cut-outs has hitherto been confined to lights hung from the cut-out by a flexible twin conductor. The flattened shape of the cut-out shown in Fig. 1 permits of its use with a swinging light hung from it by a length of metal tubing. To effect this end, the cover of the appliance is provided with a universal joint, to which is attached the tube, Fig. 4. The light can be swung to a considerable distance from its normal point of rest, returning thereto much more quickly than is the case with the flexible cord pendant. The many advantages for store lighting and similar work presented by this arrangement are obvious.

FIG. 4.—EDISON CUT-OUT.

The Pennsylvania Lamp.

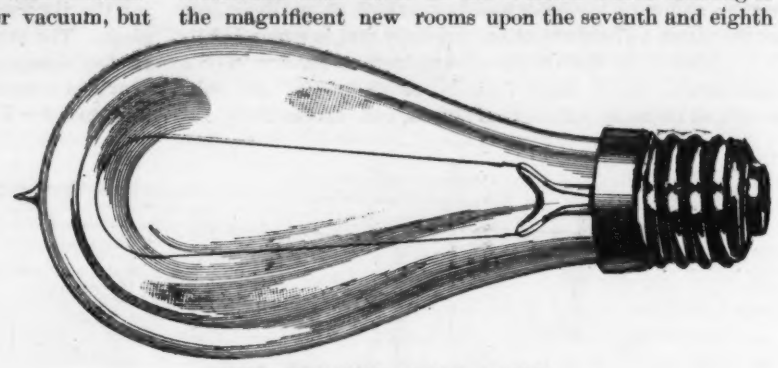
One of the most important branches of electrical industry is the manufacture of incandescent lamps. The demand is for efficiency, which means economy of operation and reasonable length of life, which should be at least 600 hours.

The usual claim of ten lamps per horse power is made for incandescent lamps, and an average life of 600 hours, although it is a very rare occurrence that they bear out the claim. This is largely due to the vapor of mercury contained in the bulb, which acts injuriously upon the filament, conveying minute particles of carbon contained therein to the interior walls of the bulb, causing it to become blackened, cutting off much of the light, besides emitting considerable heat. Until recently all lamp work has been done with mercurial pumps. The Pennsylvania Electric Engineering Company, of Philadelphia, has lately put upon the market a new lamp, shown in the illustration, which it claims has all the merits of the best lamps made, besides overcoming the difficulty presented by the vapor of mercury. This lamp is exhausted with mechanical pumps, which produce not only a higher vacuum, but secure far more uniform results it is stated, than it is possible to obtain by the old method. The manufacturers claim that, with the process of mechanical pumping, a lamp can be produced which shall have an average life of 1,000 hours, and can be successfully operated, maintaining 14.2 sixteen candle power lamps per horse power.

The following is a reported test, made by an electric expert:

Candle Power (English Standard).	E. M. F. in Volts.	Current in Ampères.	Energy Consumed in Watts.	Efficiency. Watts per C. P.	Lamps per Horse Power.
16	50	1.02	51	3.19	14.2
16	75	.70	52.5	3.28	14.2
16	100	.54	54	3 37	13.8
16	110	.50	55	3.44	13.5
25	50	1.55	77.5	3.10	9.6
25	100	.80	80.8	3.20	9.3
32	50	2.02	101	3.16	7.4
32	100	1.00	100	3.12	7.5
50	50	3.30	165	3.3	4.5
50	100	1.70	170	3.4	4.4
75	50	4.90	245	3.26	3.0
75	100	2.60	260	3.46	2.9
100	50	6.85	342.5	3 42	2.2
100	100	3.60	360	3.60	2.1
125	150	2.80	420	3.36	1.7
150	50	10.00	500	3.33	1.4
150	100	5.40	540	3.60	1.4

Other notable features claimed for this lamp are the unusual brilliancy of the light, graceful uniformity of the bulbs, and length of filament. Altogether, it would seem to be a lamp of the highest grade of manufacture.



THE PENNSYLVANIA LAMP.

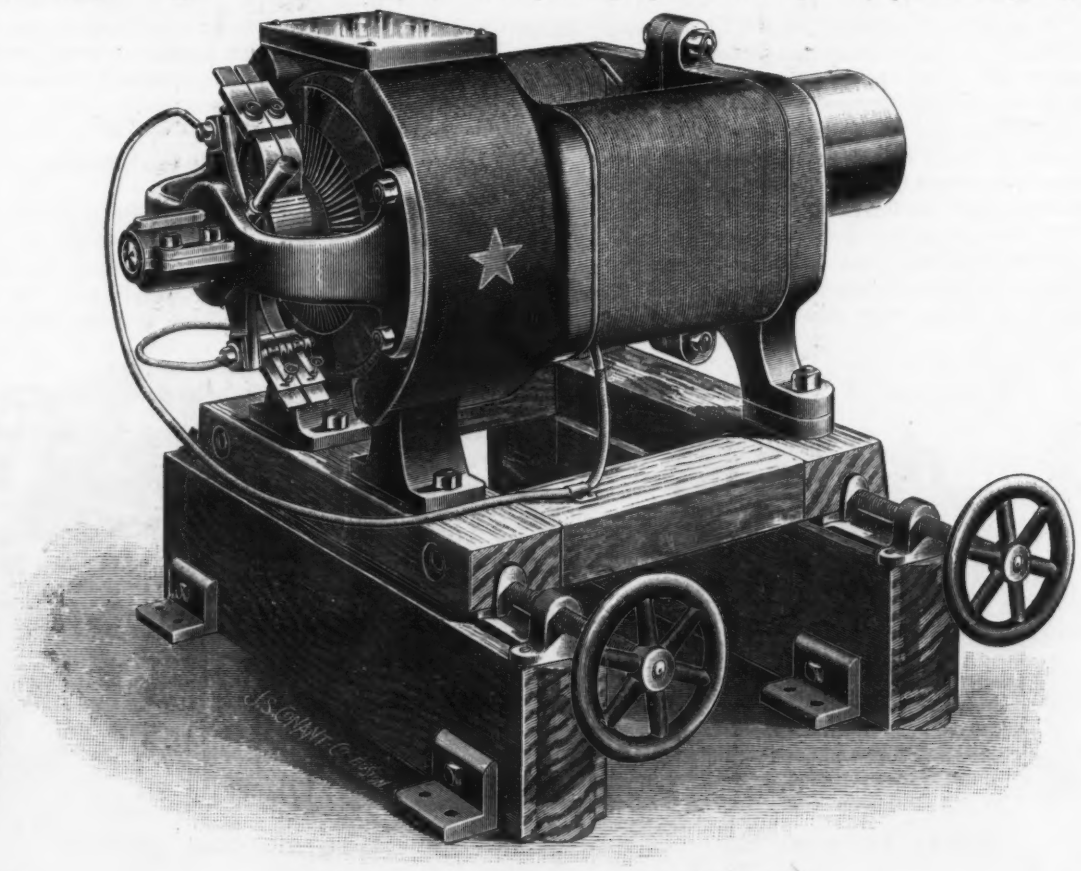


FIG. 1. THE JENNEY STAR MOTOR.

FIG. 2.—THE JENNEY STAR GENERATOR.

The Jenney Star Motor and Dynamo.

The illustrations show a new motor and dynamo, both of which embody several new features that are claimed to be of great value, both as regards first cost of apparatus and economy in the use of current. The motor shown in Fig. 1 is one and one-half horse power. It has a Gramme armature hung on fibre discs with self oiling bearings. The brushes are of a peculiar design, being composed of four carbon pencils in each, and are self adjustable. It is very simple, compact and easily managed and it is further claimed that it weighs at least one-third less than others of the same power and efficiency. It is manufactured by the Jenney Star Electric Company, Boston, Mass.

The dynamos, shown in Fig. 2, manufactured by this company, are giving good satisfaction, it is stated, wherever they are used. They are said to govern very closely and to require very little attention. James A. Jenney is the inventor and president of the company, and A. W. Rounds, treasurer, both of whom are well known among electrical people.

A Surprise for Manager Dealy, of the Western Union.

The opening of the new Western Union operating rooms and the transfer of the operating department from the fourth and fifth floors of the Western Union building to the magnificent new rooms upon the seventh and eighth floors was very quietly effected at five o'clock Sunday morning, Feb. 21. There was no confusion or delay experienced in making the change from the old quarters which the operators have occupied since the fire of July 18, 1890. The details had been so thoroughly mastered that in less than a quarter of an hour every circuit in use at that time of the day was in operation, and when the Sunday force, which comes on duty between 8 and 9 A. M., arrived they found everything working smoothly and in readiness for the day's business.

Monday, Feb. 22, being a holiday the business was somewhat lighter than usual, but a stranger would not have been able to notice the difference. The sounders were making their ceaseless din, and the message carriers were whizzing rapidly to and fro as Mr. W. J. Dealy, the manager, came upon the eighth floor about 9 o'clock. He passed rapidly up and down the room, greeting each one he met with a cordial shake of the hand, stopping occasionally to say a few pleasant words to some of the older employés.

His arrival seemed to have become known in all parts of the operating department at once. The operators began to crowd up from the seventh floor, and it was evident something was about to happen. As he reached his desk he was greeted by office messengers Miss Minnie Fennell and Master Frank Mallon, who offered congratulations for their departments. By this time the room was filled with the employés, who one and all appeared to be very anxious that Mr. Dealy should open his new desk. When he did so a complete surprise awaited him. In the desk, with a card attached, simply saying, "From the employés of the general operating department," was a beautiful and costly gold watch and chain, with a locket having a brilliant diamond in the setting, and a handsome pair of sleeve buttons.

The next pleasant incident of the day happened about 11 o'clock, when the general manager, Gen. Eckert, made his appearance upon the eighth floor.

Dr. Norvin Green, the president, came in later to inspect the new rooms, and was also received with an ovation.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

NEW YORK, Feb. 27, 1892.

The tendency of prices in the stock market this week has been downward, and the prevailing conditions have been only weak and unsettled. It has been pre-eminently a professional market, the bearish element prevailing, and successfully counteracting all influences of strength and any upward movement. The selling of European securities has been a depressing feature; and then, too, the shipments of gold from New York have served as a successful point to inspire fear among the brokers, and the effect has been evident at once upon the market. The electrics have partaken of the same weakness as the other stocks, and returned to former low prices. Thomson-Houston has fallen off to about 57, and Edison to 94; but on the other hand we note a good strength in Westinghouse, maintained, no doubt, by the opinion which gains credence that the consolidated company will find a place for this property in the new combination. Fort Wayne has also developed strength, in the face of a weak market, and becomes another exception on the list. The fiscal year of the company closes Feb. 29, and it is known that when the figures are published they will show even more favorable returns than ever before.

The Western Union Telegraph Company's stock has been unusually strong and active of late and has reached good figures. It is predicted that it will reach par before it does 85 again. This week it reached 88¾, the highest since 1882, when it sold at 98. In 1884 it fell to 49, which is the lowest price in ten years.

Northwest Thomson-Houston Electric Company stock has been listed on the Boston Stock Exchange. A considerable amount of this stock has recently been handled privately in Boston, and it promises to have some activity now that it is on the Exchange.

The Joint Committee of the Edison-Thomson-Houston Companies issued Feb. 25 a circular letter to all stockholders requesting them to deposit their stock with the trust companies on or before March 7. Ninety per cent. of the Thomson-Houston stock, and more than a majority of the Edison stock, has already been deposited, and since the plan has thus been accepted this circular will hasten its completion, and bring about an organization at an earlier date than was anticipated.

Annual Reports.—The Victoria, B. C., National Electric Tramway and Lighting Company, at its annual meeting, showed a credit for the previous year of $19,000, with receipts of $78,000; the Commercial Electric Company, Detroit, Mich., capital stock, $25,000; paid in, $7,825, real estate, none; personal estate, $7,942.19; debts, $30,830.25; credits, $39,077.12.

The Accrued Interest on the Scrip of the Westinghouse Electric and Manufacturing Company, the directors of the company have decided, shall be paid to the holders of record, on the 15th day of March.

To Issue Bonds.—The Fort Clark Horse Railway Company, of Peoria, Ill., will hold a meeting on March 11 to vote upon a proposition to create and issue bonds of the company to the amount of $250.000; the Detroit Electric Light and Power Company, at a recent meeting, decided to issue $350,000 in gold bonds, which will be guaranteed by the Fort Wayne Electric Company.

Increase in Capital Stock.—The directors of The Victoria (B. C.) National Electric Tramway & Lighting Company have been authorized to issue $100,000 additional stock; the Chicago Telephone Company has increased its capital stock from $2,000,000 to $5,000,000; the Ries Electric Specialty Company, of Baltimore, Md., at the last meeting of the board of directors voted to increase the capital to $150,000, of which $50,000 will be preferred, to bear interest at the rate of six per cent.; the capital stock of the Olean (N. Y.) Electric Light and Power Company has been increased from $30,000 to $35,000; the Buffalo (N. Y.) Crosstown Street Railway Company has petitioned the State Board of Railroad Commissioners for authority to increase its capital stock from $500,000 to $1,500,000 for purposes of proposed electrical equipment; the National Electric Manufacturing Company, Eau Clare, Wis., has increased its capital stock to $200,000, all paid in, Mr. George B. Shaw continuing as general manager. Mr. C. A. Daigh, of St. Paul, subscribed for $50,000 in stock and was elected vice-president of the company.

Coupons of the first mortgage bonds of the Edison Electric Illuminating Company, of New York, are now being paid at the New York Guaranty and Indemnity Company.

Closing Quotations.—The following were the closing quotations of electric stocks on Saturday, Feb. 27, 1892, in New York and Boston:

NEW YORK QUOTATIONS.

Name of Stock.	Par.	Capitalization.	Bid.	Ask'd.
Western Union Telegraph Co	100	86,200,000	88½	88⅝
Commercial Cable Co	100	7,716,000	149	150
Edison General Electric	100	15,000,000	98	98½
Consolidated Electric Light	100	2,500,000	20	30
Edison Illuminating Co., of New York	100	4,500,000	81½	82
" " " Brooklyn	100	750,000	74	78½
" " " Chicago	100	750,000	138	142
U. S. Illuminating Co	100	1,250,000	30	35
Edison Elec. Light Co. (of Europe) stock	100	2,000,000	2½	5
" " " " bonds	sh	30,000	65	75½
" Ore Milling Co	100	2,000,000	17¼	22½
" Toy Phonograph Mfg. Co	10	1,000,000	....	½
U. S. Electric Light Co	100	1,500,000	15	20
Brush Illuminating Co., of New York	50	1,000,000	40	50
Mt. Morris Electric Light Co	..	500,000	20	40
East River Electric Light Co	100	1,000,000	....	60
North American Phonograph Co	...	6,600,000	4½	6
New York Phonograph Co	...	2,000,000	3	4
Automatic Exhibition Co	...	2,000,000	2	2½
New England Phonograph Co	...	2,000,000	1¾	2¾

BOSTON QUOTATIONS.

	Par.	Capitalization.	Highest.	Lowest.	Bid.	Ask'd.
Thomson-Houston Elec	25	6,000,000	60¼	57⅛	58½	59
Thomson Houston Elec. preferred	25	4,000,000	28¾	28	28½	29
Thomson-Houston Elec.—Series C	sh	40,000	....	....	8¼	9
Thomson-Houston Elec.—Series D	sh	120,000	7⅞	7¾	7⅞	8
Thomson-Houston Int'n'al Elec	100	600,000	....	.....	200	210
Thomson-Houston Int'n'al Elec—Pfd	100	400,000	....	....	102½	104
Thomson Elec. Weld	100	1,000,000	60	....	60	....
Thomson European Elec. Weld	100	1,500,000	12½	....	12½	15
Westinghouse Elec.—Pfd	50	10,000,000	26	24	24½	25½
Westinghouse Elec.—Trust receipts	..	.....	15⅞	15	15	15½
Fort Wayne Elec	25	4,000,000	13⅞	13⅝	13¾	13⅞
Fort Wayne Elec.—Ser A.	sh	80,000	7¼	....	7⅛	7¼
Detroit Elec	10	1,000,000	8	....	8	8¼
West End St. Ry. Co.—Com	50	7,150,000	73¼	73	73¼	73½
West End St. Ry. Co.—Pfd	50	6,400,000	84¾	84½	85	85¼
American Bell Tel	100	15,000,000	209½	209	209	209⅜
Erie Tel. & Tel. Co	..	4,800,000	45¼	....	45	46
Mexican Tel. Co	10	1,280,000	....	....	105	110
New Eng. Tel. & Tel. Co.	..	10,304,800	....	....	51½	52½
Tropical Tel. Co	10	400,000	....	....	30	50

Chicago Quotations.—Col. S. G. Lynch, broker, 153 Monroe street, Chicago, furnishes quotations on electrical stocks as follows:

TELEPHONE STOCKS.

Chicago	$230	@ $232	Cumberland	$60	@ $62
Central Union	56	@ 57	Wisconsin	118	@ 120
Michigan	81	@ 83	Bell of Missouri	175	@ 180
Great Southern	30	@ 32	Iowa Union	20	@ 22
Colorado	34	@ 36	Missouri & Kansas	51	@ 53
Rocky Mountain Bell.	40	@ 43			

ELECTRIC LIGHT STOCKS.

Chicago Arc Light and Power	$87	@ $89	Chicago Edison Co	$155	@ $165

NEW INCORPORATIONS.

The Mitchell Electric Company, of St. Paul, Minn., has been incorporated with a capital stock of $15,000.

The Constantine Electric Company, of Constantine, Mich., has been incorporated with a capital stock of $6,000.

The American Rapid Motor Company, of Trenton, N. J., was recently formed. Louis Ernst is president, and the capital is $1,000,000.

The Siemens-Halske Electric Company of America is a recent company formed in Chicago. Edwin F. Bailey is president and the capitalization is $500,000. Its purpose is to manufacture electrical devices.

The Marseilles Electric Light and Power Company, of Marseilles, Ill., capital stock, $25,000, has been formed to operate an electric light and power plant. Clarence Griggs, C. L. Stinson and J. M. Grantham are the organizers.

The Roseburg Electric Light Company, of Roseburg, Oregon, with a capital stock of $20,000, has been incorporated to erect an electric light plant, etc. J. E. Hurd, O. Boon, and L. L. Hurd, all of Roseburg, are the incorporators.

The Oak Terrace Cold Storage Company, of Jacksonville, Fla., with a capital stock of $25,000, has been formed to manufacture ice, etc., generation of electricity for light and other purposes. T. H. Butler, J. M. Foggerty and W. T. Chapin.

The Anna, Jonesboro and Asylum Electric Street Railway Company has been organized at Anna, Ill. It will construct and operate an electric railway between the three points named. Jno. H. Spann is president. Capital $100,000.

The American Elevator Company, of Milwaukee, Wis., capital stock $500,000, has been formed to manufacture and sell hydraulic, steam and electric engines and elevators. E. H. Smith, S. R. Miller, Wm. J. Kayser and L. M. Sherman are the organizers.

The Hubinger and Pool Company, of New Haven, Conn., with a capital stock of $50,000, has been started to manufacture, buy, sell and deal in dynamos, motors and electrical apparatus, etc. J. E. Hubinger and N. W. Hubinger, of New Haven, are the organizers.

The Canton Waterworks and Electric Light Company, of New Orleans, La., with a capital stock of $50,000, has been incorporated to operate water works and electric light plants in Canton. The promoters are Irwin Jamison, L. E. Conas, Roland C. Perkins, all of New Orleans.

The Deer Lodge Electric Company, of Deer Lodge, Mont., with a capital stock of $25,000, has been organized to construct and use electric plants and railways, etc., etc. Nicholas J. Bielenberg, Samuel L. Larabie, Conrad Kohers and Henry Reed, of Deer Lodge, are the incorporators.

The Diamond Incandescent Lamp Company, of Denver, Colo., capital stock, $50,000, has been formed for the purpose of manufacturing and selling incandescent electric lamps and brackets, etc. The incorporators are Samuel S. Campbell, Jno. W. Flintham, Moses L. Stern and W. H. Brevoort.

The Curtis Electric Company (incorporated in W. Va.), of Brooklyn, N. Y., with a capital stock of $500,000, has been formed to produce and furnish electric light and power, and to manufacture and deal in electrical appliances. Byron A. Beal, W. W. Pratt and E. B. Hooper, all of Brooklyn, are the promoters.

The Duwamish Construction Company, of Seattle, Wash., capital stock, $200,000, has been incorporated to build and maintain street railways in Seattle; to operate and maintain electric light and power plants, etc., etc. J. S. Patterson, A. Mackintosh and H. L. Thomas, all of Seattle, are interested in this company.

The Carbon Incandescent Gas Tip Company (incorporated in W. Va.), of New York City, with a capital stock of $500,000, has been formed to manufacture and sell gas tips, burners and fixtures of every kind for gas or electricity. I. Samuels, Benj. F. Devoe and Wendel Samuels, all of New York, are the incorporators.

The Warren Investment Company, of Indianola, Ia., with a capital stock of $500,000, has been incorporated to deal in real estate, etc., and to build an electric road from Des Moines to Indianola. John A. Campbell, C. P. Campbell, J. McKenzie Cleland, Theodore P. Shontz and J. H. Carruthers, of Chicago, Ill., are the organizers.

The Merchants' Lighting Company, of Santa Rosa, Santa Rosa, Cal., with a capital stock of $50,000, has been formed to operate electric light and gas plants, and to distribute light and power, etc. J. H. Bruch, M. H. Dignan, Wm. E. Stahl, I. A. Proctor, T. P. Keegan, J. H. Einhorn and C. A. Wright, all of Santa Rosa, are interested in this concern.

The Land and Improvement Company of New Alexandria, of Fairfax, Va., with a capital stock of $1,000,000, has been incorporated to purchase real estate, factories, etc., erect telephone, telegraph and electric works, etc. G. E. Abbott, of Bryn Mawr, Pa.; P. Agnew, of Alexandria, Va., and L. W. Spear, of Duluth, Minn., are the organizers.

The Black Hills Electric Railway Company, of Hot Springs, S. Dak., with a capital stock of $250,000, has been started to construct and operate a railroad from Hot Springs to Cascade, a distance of eight miles. W. E. Lenhart and W. E. Penrice, of Chicago, C. G. Fargo and Jas. E. Parke, of Hot Springs, and A. Greely, of Nashua, Ia., are the promoters.

The Chicago Insulated Wire Company, of Charles City, Ia., capital stock, $500,000, has been incorporated to buy and sell all kinds of metal used for electric lighting, electric supplies and fixtures. Wm. H. McKinlock, M. A. Knapp, N. P. Lucas, E. R. Baker, W. P. Pearson and William Alton, Jr., of Chicago, and E. Buck, of Charles City, are among those interested.

The Hollister Light and Power Company, of Hollister, Cal., with a capital stock of $25,000, has been formed to produce light from fuel, and distribute same, maintain electric light plants and furnish light and power. Thos. Donovan, E. A. Crepin, of Hollister, F. E. Kenney, Wm. Kalentag, A. Towne, Thos. McMahon, G. S. Nash, all of San Francisco, are the promoters.

The Egg Harbor City Water, Electric Light and Power Company, of Egg Harbor City, N. J., has been incorporated, capital stock $30,000, all paid in. The objects of the corporation are to erect water works, electric light plant, and to maintain and operate the same. The incorporators are John M. Mays, William R. Cason and William W. Taylor, of Philadelphia; Chas. W. Cason, of Camden, and Henry May and Henry Kuehnle, of Egg Harbor City.

The Paso Robles & Cayucos Railroad Company, of Paso Robles, Cal., with a capital stock of $700,000, has been formed. to build and operate a railroad 30 miles long by steam or electricity; also telegraph lines, wharves and steamships and to deal in real estate. The incorporators are G. R. Adams, H. Eppinger, A. F. Jack, E. A. Stowell, O. C. Bryant, all of Paso Robles, M. M. O'Shaughnessy, J. N. E. Wilson, both of San Francisco, J. W. Watson and A. M. Hardee, both of Cayucos.

AFFAIRS OF THE COMPANIES.

The Brush Electric Company, of Cleveland, O., will hold its annual meeting on Tuesday, March 15, at 2:30 P. M.

The Louisville, Ky., Electric Light Company has elected the following officers; President, H. Bishop; vice-president, G. W. Morris; secretary, J. H. Gilbert.

Birmingham, Ill.—The plant of the People's Electric Light Company was recently sold under mortgage, and purchased by Mr. J. F. B. Jackson for $15,300. It is not known what disposition will be made of the property, but it may be run in connection with the Consolidated Electric Light Company.

The Canton Electric Light and Power Company, of Canton, N. Y., at its annual meeting elected the following officers: President, Geo. W. Seymour; secretary, Albert T. Martyn; superintendent, Luman Bailey; treasurer, Murray N. Ralph. The old board of directors was continued in office.

The Burlington Gas Light Company, of Burlington, Vt., and the Citizens' Electric Light & Power Company have united their interests and organized under the title of the Consolidated Electric Company, with a capital stock of $150,000, the controlling interest being held by the Gas Light Company.

The Hartford (Conn.) Electric Light Company at its recent annual meeting elected the following directors: A. C. Dunham, T. O. Enders, Leverett Brainard, William H. Bulkeley, William H. Goodrich, W. O. Burr, Atwood Collins, E. B. Bennett, Henry Roberts, Rodney Dennis, Howard M. Clark.

The Columbus & Westerville Electric Railway, of Columbus, O., at its annual meeting, elected the following directors: Messrs. H. M. Neil, T. H. Simons, Adam Innis, G. W. Meeker, A. B. Kohr, F. H. Croughton and C. E. Bell. Action was taken for an immediate application for a franchise for the company. The directors elected officers as follows: President, H. M. Neil; vice-president, T. A. Simons; secretary, G. W. Meeker; treasurer, Adam Innis; attorneys, Merrick & Tompkins.

The Youngstown Electric Light Company, of Youngstown, O., and the Youngstown Gas Company and the Mahoning Electric Light Company have effected a combine, it is stated, by the trading of stock. The Mahoning Electric Light Company, at its annual meeting, elected its old board of directors and officers. The Youngstown Electric Light Company also has elected the same board of directors, and the latter elected John Smith, president; B. P. Holmes, secretary, treasurer and general manager.

A name is wanted for the new consolidated Edison-Thomson-Houston Company. Many have been proposed, but they so nearly resemble the names of existing or defunct companies, that a new one must be found. "Consolidated," "National," "Columbian," "General," are among those that have been suggested. To be sure the name is not of vital importance, but still it must have character, and will be chosen as carefully as possible that it may reflect credit upon the importance and strength of this new combination of forces.

The Federal Street & Pleasant Valley Passenger Railway Company, of Pittsburgh, Pa., will hold a meeting of the stockholders April 19 for the purpose of voting for or against an increase of the capital stock of the company of $100,000 for the purpose of carrying into effect the merger or consolidation of the Allegheny Street Railway Company, the Allegheny & Bellevue Passenger Railway Company, the Perry Street Railway Company and the Troy Hill Passenger Railway Company with the Federal Street & Pleasant Valley Passenger Railway Company.

The Wilmington (N. C.) Street Railway Company has elected the following officers: President, E. L. Hasks; vice-president and general manager, J. H. Barnard; secretary, B. F. O'Connor; treasurer, J. G. White. The authorized capital of the company is $300,000, of which $100,000 is paid up The company is now changing its motive power from horses to electric motors. The contract for cars and rails has been given to the Lewis & Fowler Manufacturing Company of Brooklyn. The Ball Engine Company, of Erie, Pa., is to furnish the steam plant, while the track laying and construction is to be done by J. G. White & Co., of New York City. This firm also acts as consulting engineers for the balance of the work. The company has eight cars and seven miles of track, including 1½ miles of steam road connecting all the steam railways that enter Wilmington.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-177 TIMES BUILDING, NEW YORK, Feb. 29, 1892.

Mr. H. B. Spiegle, of the Fire Alarm Electrical Company, of Cleveland, O., called at our office last week. Mr. Spiegle is an enthusiastic worker for his company, and if anyone can get business he can.

Thomas Dolan, a well-known telegrapher, formerly night manager of the Western Union main office in this city, was found dead on the steps of his residence early last Sunday morning. He had died of apoplexy.

Mr. H. W. Shurtz, secretary and treasurer of the Northwest Electric Engineering Company, of Portland, Ore., called at our office on Thursday of last week. He is East on very important business, the happy result of which will be referred to later in THE ELECTRICAL WORLD.

The East River Electric Company was awarded the contract to light 16 lamps on Fifth avenue from Twenty-third street to Forty-second street, last week at the meeting of the Gas Commission. The price to be paid is 50 cents a lamp instead of 60 cents, which the company first demanded.

Commodore Ralph Shainwald, President of the Standard Paint Company, has returned from his California trip. Apropos of the same, the news reaches us that the city of San Francisco is at present making great improvements in its harbor facilities; hereto-

fore the piling used has been of uncertain life on account of the teredo, but all this trouble has now been overcome by winding the piling with canvas, and then impregnating it with "P. & B. "paint. This is the only compound that has ever proved successful. The San Francisco Gas Lighting Company is also putting in half a mile of new wharf, treating all boards and piles with P. & B.

Mr. W. H. Brown, of the United States Electric Light and Power Company, Times Building, this city, is being praised by the daily papers because he chastised in a vigorous manner, with his silk umbrella, on Broadway, on Friday night, a "masher," who persisted in talking to Mr. Brown's daughter, who was walking along the street for a few moments, unattended, while her father called at a store to make a purchase. In addition to the thrashing, the "masher" was also arrested and sent to the Blackwell's Island penitentiary for six months. Mr. Brown's energetic action seems to have earned him the gratitude of a large number of his fellow-citizens.

New Yorkers Want Cheaper Telephone Service.—Mr. James H. Howard, of the Tropical American Telephone Company of this city, has been writing to the daily papers in connection with the agitation now going on for a reduction of telephone rentals. He says that the instruments for which subscribers in this city are charged $150 per annum, cost but $3.42 to manufacture, and that the Tropical American Company sells for export a complete subscriber's outfit for from $15 to $17. The Metropolitan Telephone Company charges $90 extra, or $240 a year, for a long distance instrument, which the Tropical American Company sells outright for export for $20. Mr. Howard adds: "Montreal, just across our border, pays $35 a year and has single lines to each subscriber and metallic circuits. Berlin and most German cities pay $3 to $3.50 a month. London subscribers pay £10 per year, equal to $4 a month. At Barbados and Trinidad the rates are $2.50 to $4 a month for residences and business houses respectively. In Venezuela $36 a year is the ruling rate. In Mexico City, $60 a year or $5 a month is charged."

L. H. H.

PHILADELPHIA NOTES

Branch Office of The Electrical World,
927 Chestnut Street, Philadelphia, Feb. 27, 1892.

The Chester Steel Castings Company, Chester, Pa., makes castings of all sizes, especially for electrical work.

G. W. Schultz & Co., of Philadelphia, are in the market for broken incandescent lamps, scrap copper and old machinery.

Mr. H. T. Paiste has returned from an extended western trip. He proposes introducing some entirely new goods in a very short time.

Messrs. Gill & Co., the proprietors of the Washington Flint Glass Works, Philadelphia, manufacture every style of glass work used in connection with the electrical business.

Vallee Brothers & Co., of Philadelphia, are introducing a new adjustable arc lamp clutch for Thomson-Houston lamps. They claim that it is practically indestructible.

The Century Pottery Company, Camden. N. J., makes a specialty of odd shapes in electrical porcelain work, and is also an extensive manufacturer of rosettes, cut-outs, branch and line blocks.

The Fottrell Insulated Wire Company is making a specialty of its patent underground cable. This company also manufactures insulated electric wires and cables for all purposes, and reports the receipt of several large orders.

The Pennsylvania Electrical Engineering Company, Philadelphia, has recently installed a 500-light National alternating dynamo at Millville, N. J., for the Millville Electric Light Company. They have also secured the agency for the Standard Electric Time Company, using the Warner system.

The Harrison Safety Boiler Works, of Philadelphia, manufacture boilers ranging in size from 4 to 240 h. p. They claim as advantages that the boilers are easy of transportation, easy to erect and to repair, and combine maximum safety, economy of fuel and durability. It is said they are specially advantageous for isolated plants.

J. W. Parker & Co. report the following sales for "Ball" engines for one week: One 60-h. p. compound Ball engine for Leesburg (Va.) Electric Light Company; one 125-h. p. standard Ball engine for Doylestown (Pa.) Electric Light Company; one 250-h. p. standard engine for North Hudson Electric Railway Company, of Hoboken, N. J.

The Thomson-Houston Electric Light Company, of Philadelphia, reports the following sales: A 500-light incandescent dynamo to Christian Schmidt's brewery; a 50-light incandescent dynamo to H. Lutz, Thurlow, Pa.; 300-arc-light machine to Carnegie Bros. & Co., of the Homestead Steel Works, and a 90-h. p. generator to the Central Iron Works, of Harrisburg, Pa.

A Well Equipped Plant.—The plant erected by the Heisler Electric Company, for the corporation of West Toronto Junction, Ont., has been inspected and formally accepted by the town authorities. Mr. J. J. Wright, the inspector, speaks very highly of the installation. The Heisler Company also reports the sale of a plant at Constantine, Mich., made through their agents, Messrs. Rheubottom & Board of Union City. These gentlemen are doing excellent work in their territory, and are meeting with deserved success.

W. R. W.

NEW ENGLAND NOTES.

Branch Office of The Electrical World,
Room 28, Hataway Building, 620 Atlantic Ave.,
Boston, Mass., Feb. 27, 1892.

Mr. C. J. Mayer, representing the R. D. Nuttall Company, was in the city for a few days this week.

The Wilson Incandescent Lamp Company has established offices at 114 Bedford street, Boston.

B. F. Sturtevant & Co., of Boston, have just shipped one of their direct connected motors and fans to Bolivia, S. A., to be used in mine ventilation.

Mr. Charles L. Edgar, general manager of the Edison Electric Illuminating Company, of Boston, who has been away for several weeks for the purpose of recuperating his health, has returned to the city.

Lynn, Mass.—The monster 500- h. p, electric generator for the West End Railway Company, of Boston, is still in Factory K, and receiving much attention from recent visitors to the works. It will soon, however, be shipped to the West End Company.

The Eastern Electric Light and Storage Battery Company, of Lowell, Mass., has just issued an interesting pamphlet on the subject of storage batteries, in which those interested in this subject will find considerable valuable information.

Chelmsford, Mass.—A hearing is to be granted March 2 by the selectmen of Chelmsford on the petition of the Lowell & Suburban Street Railway Company for the right to lay tracks through Chelmsford street to Chelmsford Centre and to use electricity as a motive power.

Mr. George W. Mansfield, recently gave an address on motive power as applied to steam and street railways before the New Bedford, Mass., Board of Trade. Mr. Mansfield has been engaged as engineer for the new Globe Street Railway Company, and stated that the corporation intends to expend $500,000 in improving and enlarging the plant. A station having a capacity of 25,000 h. p. is to be erected.

C. A. B.

WESTERN NOTES.

Branch Office of The Electrical World,
405 The Rookery, Chicago, Feb. 27, 1892.

Mr. W. C. Stewart has been appointed electrician of the People's Street Railway and Electric Light Company, of St. Joseph, vice C. H. Rahl, resigned.

The Water Power Company, at Des Moines, Ia., has almost finished an extension to the dam opposite its station, and is installing some additional machinery.

Mr. Elmer A. Sperry's paper on "Fuse Wire," which was one of the four articles read before the Chicago Electric Club, is reprinted in a neat folder on "Tested Fuse Wire."

The Chicago Electrical Association will hereafter hold its meetings on the second and fourth Tuesdays of each month, at Room 48, Atheneum Building, 26 Van Buren street.

Crawfordsville, Ind.—Mayor Carr and several of the councilmen, of Crawfordsville, Ind., recently spent several days in Chicago and placed an order for a large amount of supplies.

Mr. William Bracken, president of the Consolidated Electric Company, is a welcome visitor in Chicago, having been called here in consultation regarding the use of electric boats at the World's Fair.

The Laidlaw & Dunn Co., of Cincinnati, O., has opened a branch office in Chicago at 199 South Canal street, where a large stock of steam pumps including duplex, single direct-acting and others will be carried in stock, together with a large quantity of general railway supplies.

Mr. F. W. Weir, of the Saginaw Manufacturing Company, Saginaw, Mich., closed some nice business arrangements in St. Paul this week. Mr. Weir is very enthusiastic over the good results obtained from the special dynamo pulley the Saginaw Company is placing on the market.

The Brotherhood of Electrical Mechanics, Chicago, gave their second annual reception and ball in Battery "D" Armory, on Friday evening, Feb. 26. Like everything else the Brotherhood has undertaken, the affair was a grand success, and reflected much credit on the several committees.

Mr. George Cutter addressed the Brotherhood of Electrical Mechanics ten days ago on the subject of "Conductivity and Insulation," showing the need of higher insulation, and the way this is met in the best modern practice. The full text of his lecture is given in the souvenir programme distributed at the Brotherhood Ball last Friday evening.

Mr. A. H. Englund, formerly secretary and treasurer of the English Merchandise Company, Chicago, has opened an office at No. 435 "The Rookery," as secretary and manager of The International Register Company. This company has purchased the Pratt patents on conductors' fare registers, and has equipped a very complete factory for the manufacturing of these machines in both portable and stationary forms. Mr. Englund's long and practical experience in the street railway supply trade has made him a host of friends, and the success of his new enterprise is assured.

F. DeL.

Tacoma, Wash., Feb. 25, 1892.

Oakesdale, Wash., now has an electric light plant in successful operation.

The Tacoma Light and Water Company has moved into its new offices in the Mason Building.

The Point Defiance, Tacoma and Edison Railroad Company has elected R. F. Radebaugh president, and Stuart Rice secretary.

Mr. H. M. Byllesly, of St. Paul, president of the Northwestern Thomson-Houston Company, has recently visited the local agencies in this State.

Mr. F. B. H. Payne, recently appointed by the Edison General Electric Company local agent in Tacoma, has opened offices in the Fidelity Building.

The Everett Electric Light and Power Company, of Everett, Wash., will operate nine miles of electric lighting circuits from the temporary plant located in the new nail works.

The Granite Falls water power is likely to be utilized by means of a high voltage system, to supply Snohomish and Everett, Wash., with current for electric light and railway purposes.

Levine's electric ore detecting apparatus, invented by a citizen of Tacoma, is being successfully used, it is stated, in eastern Washington by prospectors in the employ of Pritchard Brothers.

Mr. H. A. Craigin, an experienced street railway man and a graduate of the Massachusetts Institute of Technology, has been appointed general manager of the Tacoma Railway and Motor Company.

Fred E. Sander, of Seattle, will, it is said, gradually extend the Grant Street Electric Railway from that city to Tacoma, via the Duamish and White River valleys. Three miles of the road are now in operation.

Pacific Coast Agent Glass, of the Phonograph Company, has ordered all of the slot machines and all other phonographs not leased to private parties to be shipped to San Francisco, owing, it is said, to an injunction obtained against the main company.

The Great Northern Railway Company has opened a telegraph office for commercial business in South Westminster, B. C., and will open a branch office at New Westminster, thus entering into competition with the Canadian Pacific Railway Company.

The Westside Street Railway Company, of Olympia, Wash., J. R. Chaplin, manager, has awarded the contract to the Edison General Electric Company for the electrical equipment of two miles of road, power house and two cars, the work to be completed as soon as the track can be laid.

The employes of the Tacoma Railway and Motor Company have raised a subscription for Motorman Osborne, who was recently caught by the gears while polishing the commutator of an Edison double reduction motor, and seriously injured, rendering amputation of one arm necessary.

The consolidation of the Point Defiance Railway Company with the Tacoma and Edison Railroad Company will necessitate a change in the location of the proposed power house, which the former company expected to build, and the power station of the combined companies will probably be located on the water front to insure a supply of cheap fuel.

G. R. de V.

News of the Week.

THE ELECTRIC LIGHT.

Creede, Colo., now has electric lights.

Newman, Ill., is lighted by electricity.

Bellefontaine, O., wants a new electric light plant.

Batesville, Ark., has closed a contract for electric lights and water-works.

West Oakland, Cal.—The railroad yards at West Oakland are to be lighted by electricity.

DeLand, Ga., is to have electric lights all the year round, instead of only the winter months, as formerly.

North Baltimore, O.—It is expected that by March 1 North Baltimore will be illuminated by electric lights.

Lynn, Mass.—The Thomson-Houston Company recently shipped an invoice of 1,400 incandescent lamps to Osacka, Japan.

Niagara Falls.—McGarigle & Sweeney have taken the contract to light the Hotel Mayle and other buildings with electricity.

An Electric Light Tower 70 feet high is being erected in the centre of Lake Manawa, Ia. Three electric lights will surmount it.

New Duluth, Minn.—A new electric plant has been put in at the Atlas Bridge and Brass Works. There are 12 arcs of 2,000 c. p. each.

The Waterville Improvement Company, of Waterville, Ore., will put in electric lights along the road between Wenatchee and Waterville.

The following towns are moving for electric lights: Girard, O.; Dundee, Mich.; Newaygo, Mich.; Lake City, Minn.; Bay View Heights, Mich.; Lehi, Utah.

Mr. D. M. Plume, of Waterbury, Conn., has been elected president of the Stafford Springs Electric Company, organized to supply electric lighting in Rockville, Conn.

Sales of Electric Light Plants.—The Coopertown (N. Y.) plant is to be sold under a mortgage March 10. The Norwich (N. Y.) electric and gas plant will be sold March 12.

London, O.—The contract for putting gas and electric light fixtures in the new Court House was let to John McHenry & Co., of Cincinnati, the price being $2,318. There were 10 bidders.

Hackensack, N. Y.—The Hackensack Edison Lighting Company is preparing to use crude petroleum as fuel under its boilers as a measure of economy. It will consume about nine barrels of oil daily.

Reading, Pa.—The city of Reading has closed a contract with the Reading Electric Light and Power Company for 250 lights or more, not exceeding 350, of 2,000 c. p., to burn every night and all night, at $109.50 per lamp.

Boone, Ia.—The City Council has granted an extension of 20 years to the charter of the Boone Electric Company, and the business will be enlarged by the addition of a 30,000-h. p. plant. Arc lights are also to be furnished.

Ellicott City, Md.—The machinery for the new electric light plant has been placed in position, and the fixtures for the lights in residences and stores are ready. All the electrical appliances were furnished by the Southern Electric Company.

Manchester, Mich., will have electric lights, the council having granted a ten-year franchise and a three-year contract for four arc lights and fifty-two candle power incandescent street lights, to the Kingsley Milling Company. The lights are to be turned on May 1. The Thomson-Houston system will probable be used.

To Be Lighted by Electricity.—The Schmulbach Brewing Company, of Wheeling, W. Va., the largest concern of its kind in the State, has closed a contract with the Edison General Electric Company, Pittsburgh, for the equipping of the entire brewery with incandescent lights. The plant is to have a capacity of 300 16-c. p. lamps.

The Buckhannon Electric Light and Power Company, of Buckhannon, W. Va., whose plant was destroyed by fire some time ago, has placed an order with the Edison General Electric Company at Pittsburgh for the reconstruction of the entire plant, consisting of station having a capacity of 750 incandescent lights and 25 1,200 c. p. arc lamps.

Mitchell, S. Dak.—The electric light plant at Mitchell has been undergoing extensive repairs and additions, as well as a change of location. The power room is 18x40 and contains a 100-h. p., Atlas engine and arc and incandescent dynamos of improved patterns. The boiler room is 20x30, with an addition 16x30. At present there are 600 incandescent lights in operation and about 15 arc lights.

The Price of Buffalo Lighting.—In the article on the electrical features of Buffalo in The Electrical World of Feb. 13th, the price of electric lighting in the city of Buffalo was given as $40 a year instead of 40 cents a night; for city lights as $30 a year instead of 36 cents a night for commercial lights. The current yearly rates being $146. 50 per light per year for all night city lighting.

ELECTRIC RAILWAYS.

The Buffalo, N. Y., Crosstown Street Railway is to be equipped electrically.

The Pittsburgh, Pa., and Castle Shannon Railway System is to be equipped electrically.

Electric Traction.—The following towns are agitating the question of electric street railways; Johnstown, N. Y.; York, Pa.; Canandaigua, N. Y.

The Thomson-Houston Company has during the past year furnished 63 new electric railways in the United States, and it has orders for five hundred 25-h. p. street railway motors unfilled.

Springfield, Mass.—The Springfield Street Railway is before the council with a petition for right to extend their lines in certain specified directions, and it is likely that their request will be granted.

Alameda, Cal.—The Alameda, Oakland and Piedmont Railroad Company has decided to use the overhead system of electric wire and the work of changing the road will be commenced in a few weeks.

New Brighton, Staten Island, N. Y.—The Port Richmond & Prohibition Park Electric Railway has secured a franchise from this village, and will build an electric road from its grounds, near the village, to the shore of the Kill Van Kull.

Asbury Park, N. J.—The board of commissioners of Asbury Park have voted to extend the franchise of the Sea Shore Electric Railway Company for a term of 30 years at an increased fee, after

the expiration of the present franchise, which has about 15 years to run.

Brooklyn, N. Y.—William Richardson, president of the Atlantic Avenue Railroad Company, has taken title to a plot of ground at Second street and Third avenue, costing $90,000, as a site for a power house for the trolley electric system, to be put in operation on the lines of the company.

Lexington, Ky.—The Belt Line Railway, of Lexington, Ky., an electric system, gives receipts for every fare paid in money and any person returning 100 receipts to the company's office gets six tickets in exchange. By that system any person who cares to treasure receipts can get 106 rides for $5.

Lansdale, Pa.—A company is being organized by M. C. Clemens, L. Rosenberger, of Harleysville, and A. C. Godshall, of Lansdale, to be capitalized for $100,000 to construct and operate an electric railway between Lansdale and Harleysville. The Thomson-Houston system will be used, it is stated.

The Fort Clark Horse Railway Company, of Peoria, Ill., will hold a meeting on the 11th of March to act upon a proposition to change the name of the company, to enlarge its powers and to make such changes in the articles of incorporation that it may equip and operate its line with electricity as a motive power.

Rochester, N. Y.—Benjamin Graham, president of the Rochester Railway Company, and Horace McKee, of Pittsburgh, one of the directors of the company, recently took a trip over the routes in Rochester, in company with the local officials. This inspection was made with a view to equipping all the lines with electricity.

Taunton, Mass.—The Inter-State Electric Railway Company, with head office at Providence, R. I., has applied for a franchise for running an electric road within the city limits, to connect this city and Providence, R. I., via Swansea, Seekonk and Rehoboth, and the purpose is ultimately to make connection with Brockton, and thence to Boston.

Haverhill, Mass.—Fred. S. Carr, on behalf of the People's Street Railway Company is before the House of Representatives, with a petition for incorporation for the purpose of building a street railway from the terminus of the Haverhill & Groveland Street Railway in West Newbury to the terminus of the Newburyport & Amesbury Street Railway.

Proposed Electric Road in the Catskills.—In connection with the new Otis Elevating Railway, which is now being built up the Catskill Mountain, from a point near Palenville to the old Catskill Mountain House, it is said that an electric railroad from the upper terminus to Hunter, with a branch to Hotel Kaaterskill is under consideration. An offer to build the road, ready for next season's business, 11 miles, for $50,000, has been made.

Annapolis, Md.—Senator Moss has introduced a bill in the Senate that is of considerable interest to the people of Annapolis and Anne Arundel County. It is to incorporate the Annapolis, Eastport and Bay Ridge Electric Railway and Power Company, with capital stock of $150,000. It is intended to establish a street railway in the city of Annapolis to run between that city and Bay Ridge during the summer season, and for lighting and power purposes.

Manchester, N. H.—A special meeting of the directors of the Manchester Street Railway Company was held recently, and it was voted that a committee consisting of Messrs. C. Williams, C. H. Bartlett and J. L. Stevens be authorized to procure surveys and estimates of costs of extension of the road, and to investigate as to the best system of motive power. A committee was also appointed consisting of Messrs. Williams, J. F. Briggs and Mr. Olzendam, to confer with the electric light companies of the city in regard to furnishing motive power for the road.

Buffalo, N. Y.—The certificate of incorporation of the Buffalo & Lancaster Electric Railway Company, to build a street railway between Buffalo and Lancaster, has been filed in the office of Secretary of State Rice by William J. Volker, of this city. The capital stock is $200,000, and George M. Browne, George Bingham, Daniel O'Grady, Ira B. Littlefield, Richard R. Ditzell, William Brennan, Charles Rossler, George A. Davis and John H. Slack are the directors of the company. Tracks will be laid, covering a distance of 20 miles, and will be from the Buffalo City limits through the Eastern boundary of the village of Lancaster. Besides the above directors, the other incorporators of the new company are E. A. Benson, A. J. Smith, Thomas F. Maloney, B. E. McConnel, Englehart Oehm, George B. Miller and Jacob Stern.

LEGAL NOTES.

In Favor of the Thomson-Houston Electric Company.—Judge Jackson, of the United States Court at Nashville, Tenn., has rendered a decision in the case of the Thomson-Houston Electric Company against the Capitol Electric Company. He gave judgment in favor of the plaintiff for $54,535.85 on first mortgage bonds and $26,048 03 due on notes. It was also decreed that the property should be sold as one plant to be paid for in 6, 12 and 18 months, with interest.

Can Electricity Be Owned.—In a criminal case brought by the Municipal Electric Light and Power Company, of St. Louis, whose electricity was alleged to have been stolen by bridging wires entering the store before the wires entered the meter, the point was raised at the trial held recently that electricity cannot be owned, as it is not in any wise under control, therefore not the goods, property or effects of any one. Judge Claiborne adjourned the case until he could thoroughly investigate the matter.

PERSONAL.

Mr. Walter G. Chase, General Manager of the Mason Regulator Company, Boston, sails for Europe on March 8, on the North German Lloyd steamer Lahn.

Lieut. Irving Hale, of Denver, Colo., is delivering a series of lectures before the Denver Y. M. C. A. On Feb. 19 his subject was "Electric Railways," and on the 26th, "Electricity in Mining."

Mr. R. MacKie, for the past two years electrical engineer of the Allied Electric Light Companies, of Cincinnati, has resigned that position to establish an office as consulting engineer in that city. Mr. MacKie was formerly general superintendent of the Ft. Wayne Electric Company, and is widely and favorably known in the profession, having been elected a member of the National Electric Light Association at the recent Buffalo meeting. His long and varied experience in practical electrics fits him peculiarly for the occupation he has adopted, in which we wish him every success.

MISCELLANEOUS NOTES.

An electric time service plant, it is stated, will probably be erected in Savannah, Ga., by the Standard Electric Time Company, of Hartford, Conn.

World's Electrical Congress.—Prof. H. S. Carhart, Secretary of the World's Electrical Congress committee, announces that it has been arranged by Mr. C. C. Bonney, president of the World's Congress Auxiliary, Mr. O. Chanute, Chairman of the Engineering Congress Committee, and Prof. Elisha Gray, Chairman of the Electrical Congress Committee, that the section of the Engineering Congress relating to electrical engineering shall be merged into the World's Electrical Congress. Due notice of this agreement from the office of the World's Congress Auxiliary will follow the recently distributed circular relating to the Engineering Congress.

Mr. Geo. H. Westinghouse has issued a circular to the stockholders of the Union Switch and Signal Company asking for proxies for the election to be held in March. He is, it is stated, the largest stockholder in the company, and does not consider that the present board of directors is a representative one. Mr. Westinghouse in a recent interview in regard to the situation is reported to have stated that the members of the present board, themselves holding but a small amount of stock, were elected at the last annual meeting by the wrongful use of proxies intended for himself, and have continued to hold their places after having been fully acquainted with the manner of their election. A number of influential business men and bankers in Pittsburgh have expressed, it is stated, a willingness to become directors of the company, and the request for proxies is on account of the desire of Mr. Westinghouse to have the support of all stockholders in order to elect a board that will strengthen the financial position of the company and actively aid in pushing its business, as without such a board he would not feel justified in continuing to give the company the co-operation and financial aid which it has received from him during the past year, with the expectation on his part that at the coming annual election the stock holders would co-operate in securing a representative board. It is understood that the present directors are desirous of being re-elected and are also asking for proxies on the ground of good management of the affairs of the company.

Industrial and Trade Notes.

The Ball Engine Company, of Erie, Pa., shipped a few days ago to the Westminster & Vancouver Tramway Company, Vancouver, B. C., three 150-h. p. engines.

The Munson Maine Slate Company, of Boston, is making a very superior article of slate for electrical purposes, and those that are using it speak very highly of it.

The Chicago Central Phonograph Company, of 141 East Van Buren street, has issued a neat circular of testimonials concerning the advantages of using the phonograph.

The Lukenheimer Brass Manufacturing Company, of Cincinnati, O., manufacturers of brass and iron steam goods, has sent out a neat calendar for 1892, illustrating the application of the "Handy" gate valve, which is manufactured by this company.

The Sperry Electrical Mining Machine Company, of Chicago, manufacturers of teasted fuse wire, is sending out a neat descriptive circular price list, which gives in full a paper on fuse wire which was read by Mr. Elmer A. Sperry before the Chicago Electric Club, which is very instructive reading.

The W. S. Hill Electric Company, of Boston, is making extra efforts to fill orders for motors, cut-outs, etc., but as yet has been unable to accumulate much of a stock on account of the demand for the goods. The company is constantly increasing its facilities, which are now double what they were a year ago.

The Germania Electric Company, of Boston, is meeting with remarkable success with its new universal shade holder, which fits any socket made. The work of removal from the shops at Cambridge to new ones at Marlboro is progressing finely, although it is not expected this will be completed until about April 1.

The Consolidated Electric Motor Company, of Boston, is placing upon the market small motors suitable for fans, sewing machines, and in fact anything requiring from one-eighth to one-half horse power, wound for battery or incandescent circuit, the demand for which is very great at present. This motor has several novel features to recommend it.

The Racine (Wis.) Hardware Manufacturing Company has recently received orders for the following installation of its engines in electrical plants: Engineering department of Ohio University, at Athens, O.; the Augusta (Ga.) Brewing Company; Port Royal, S. C.; Dallas, Tex.; Butte, Mont.; Chattanooga, Tenn.; Kalamazoo, Mich., and the Wisconsin Veteran Soldiers' Home.

The Electrical Appliance Company, of Chicago, continues to receive very strong testimonials from users of Paranite Wire from all over the country, to the effect that it successfully stands the severest tests to which it has been put and is proving entirely satisfactory. This is very encouraging for the outlook for spring business, and the Electric Appliance Company is pushing Paranite wire to the front.

The John T. Noye Manufacturing Company is putting in at Jamestown, N. Y., two 300-h. p. Noye automatic engines 18 × 30 × 30, to run at 90 revolutions per minute, to be belted direct to Short generators requiring about 250 h. p. each. The fly wheels of this engine weigh 1,500 pounds each and are 13 feet in diameter, with a belt face of 40 inches. A similar engine was put in the station of the Detroit Edison Company last summer, which is now doing excellent service.

The Standard Electric Time Company, of New Haven, Conn., has been making careful tests with a special electric motor driven by battery current for the operation of tower clocks, by which these clocks may be controlled by an accurate timepiece placed in a room where the temperature can be easily governed. No winding is required. One set of this apparatus has been operating a nine-foot dial at Lawrence, Mass., for nearly a year, and has given, it is said, perfect satisfaction through all kinds of weather, the batteries still being in good condition.

A Neat Souvenir.—The Perkins Electric Lamp Company, of Boston, Mass., is sending out to some of its friends and customers a beautiful little pocket and memorandum book bound in morocco and very handsomely finished. It contains not only a memorandum pad which can be replaced by another when its leaves have all been used, but also pockets for postage stamps and cards, as well as a nice pencil. The memorandum pad contains some facts in regard to the Perkins lamp and a useful table for calculating incandescent wiring. The little book is the handsomest thing of the kind we have ever seen, and does the Perkins Lamp Company great credit. Its friends who have been fortunate enough to receive one appreciate the company's kindness.

The Engineering Equipment Company, of New York, has entered into a contract with the Gould & Watson Company, of Boston, and under exclusive privileges, has become the sole sales agents in the East for "G. & W." line materials. Purchasers of these materials will find the Engineering Equipment Company prepared to give manufacturer's terms, as on the other lines it handles, and to fill orders from stock without delay. New designs, added to standard styles now selling largely, offer to roads and contractors an attractive variety of materials of this well-known make, and samples are now shown which none interested should fail to see. Mr. W. F. D. Crane, M. E., has charge of this department at the Engineering Equipment Company's New York offices, 143 Liberty street, and 126 Pearl street, Boston. Mr. F. A. Magee, M. E., represents the company on all their lines of electric railway materials.

The New Process Raw Hide Company, of Syracuse, N. Y., has received the following letter from Mr. C. E. Barnes, superintendent of the Plymouth & Kingston (Mass.) Street Railway Company, in regard to the durability of its gears: "Seven months ago I purchased of you some of your gears for trial. I did not have an idea that they would do the work that was represented they would do. I told your representative that they should have a fair test. In order to satisfy myself, and to be sure there was no mistake, I took the gears from one of my cars and replaced them in this way. Putting on one end of the car gun metal, on the other end your gears. I have worn two sets of the gun metal off, and your gears are in use at this time. They have had seven months wear, and I think we have about as hard a road as you will find, as we have a large number of heavy grades, and, what is more, there are heavy curves in them. I can only say that the gears have gone far beyond my expectations."

Bargain days or annual spring sales are not often announced by electrical companies, but an interesting circular just received would indicate that Queen & Co., of Philadelphia, have decided that old stock is worse than none, and the way they have cut the prices of some ammetres and voltmetres is something heretofore unknown in the instrument business. This great reduction, of course, does not apply to any of their regular stock, but they happen to have on hand a good many Ayrton & Perry spring ammetres and voltmetres which do not find so ready a sale now as formerly, for obvious reasons, explained in the circular from which we quote.

"When these ammetres and voltmetres were first placed on the market some five years ago, they were without doubt the best instruments made for both experimental and practical measurements. Their points of excellence were and still are—portability; absence of permanent magnets; constancy; and direct reading proportional scales. As a consequence we have supplied them to most of the large manufacturing companies, to many central stations, and to the principal college laboratories. Recently we have engaged extensively in the manufacture of ammetres and voltmetres for all purposes, and find that for exact work we can produce instruments of greater accuracy, and for station use of equal accuracy at a less cost than the Ayrton and Perry type. We have decided, in consequence, to insure a prompt disposal of the instrument of this make still on our shelves, and have reduced their prices fifty per cent. from last year. This reduction is made without regard to cost, and it is a rare opportunity to obtain a good ammetre or voltmetre for experimental or every day use, at a marvellously low figure."

Everybody is familiar with this type of instrument, and those wishing to take advantage of an exceptional opportunity should send to Queen & Co. for a copy of circular No. 275.

Business Notices.

The Mather Electric Motors combine the highest efficiency and workmanship consistent with a reasonable first cost. Perfect automatic regulation of speed from no load to full load. For catalogues and information address E. T. Pardee, agent, 14 Butler Block, Syracuse, N. Y.

His Lordship's Opinion.—Among the guests at Dave Isaac's Prospect House, Niagara Falls, is Lord Rommilly of England, who came over from the chalked face isle to see America, and especially to ride on the Empire State Express, which is now all the talk in the London clubs. He was a passenger on the train from New York last Tuesday and passed through Buffalo, going direct to the Falls. Though he acknowledges the grandeur of the cataract in its winter garb, he says he shall return home, believing that railway traveling in America is superior to that in any other country on the globe. And that's a good deal for an Englishman to say, don't you know?—*The Courier, Buffalo, Jan. 22, 1892.*

Mme. Patti Caught by Ice at Niagara.—A cold day at Niagara Falls produces a most gorgeous display of frozen spray and ice, and wonderful crystalline formations of myriad shapes and sizes. At mid-day the sun's rays transform the scene into one of dazzling brilliancy.

Mme. Adelina Patti spent a day recently at the Falls seeing the sights and thus described her impressions:

"It is too beautiful, too inspiring for words. The white mantle of snow; the brilliant ice and scenery and the tone effects soften and beautify the scene wonderfully. I never realized how great a difference it would create, never saw such remarkable scenic effects. How grand some of these would be on the stage. They would inspire me to sing as I never sang before. Just look into that grotto! Why, that would be worth coming thousands of miles to see. I love nature, and here you can see her grandest work in all its wondrous beauty."

Twenty trains a day reach the great cataract in winter; and over forty per day in summer, via the New York Central.

Wonderful Word-Painting.—The following is an extract from a sermon of Rev. T. De Witt Talmage, in Brooklyn Tabernacle, Sunday evening, Nov. 1, 1881: "When last Thursday the swiftest train on earth pulled out from Grand Central Station for Buffalo we started on a wondrous journey. The autumnal forests were in a blaze of splendor. Four hundred and forty miles of pageant! Let artists stand back when God stretches his canvas. Along by the Hudson, and up and down the sides of the great hills, there was an indescribable mingling of gold and orange and crimson and saffron, now sobering into drab and maroon, now flaming up into solferino and scarlet. Here and there the trees looked as if their tips had blossomed into fire. In the morning light the forests seemed as if they had been transfigured, and in the evening hour they looked as if the sunset had burst and dropped upon the leaves. In more sequestered spots, where the frosts had been hindered in their work, we saw the first kindling of the flames of color in a lowly sprig; then they rushed up from branch to branch until the glory of the Lord submerged the forest. Here you would find a tree just making up its mind to change, and there one looked as if wounded at every pore, it stood bathed in carnage. Along the banks of the Mohawk there were hills over which there seemed pouring cataracts of fire, tossed up and down and every whither by the rocks. The most beautiful sight I ever witnessed was along the Mohawk Valley. Through some of the ravines we saw occasionally a foaming stream, as though it were rushing to put out the conflagration. Even the humble bush, like the bush that Moses saw, was 'burning, but not consumed.' If at one end of the woods a commanding tree would set up its crimson banner, the whole forest prepared to follow. If God's urn of colors were not infinite, one swamp that I saw along the New York Central would have exhausted it forever. It seemed as if the sea of divine glory had dashed its surf to the tip top of the crags, and then it had come dripping down to the lowest leaf and deepest cavern."

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

U. S. PATENTS ISSUED FEB. 23, 1892.

469,241. Molding for Electric Wires; Walter Gritten and Arthur Parmley, of London, England. Application filed April 27, 1891. In an insulating device, a casing, beading or molding, made of thin strips of fibrous non-combustible material held together by a suitable non-combustible adherent and having longitudinal grooves therein for the reception of electric wires.

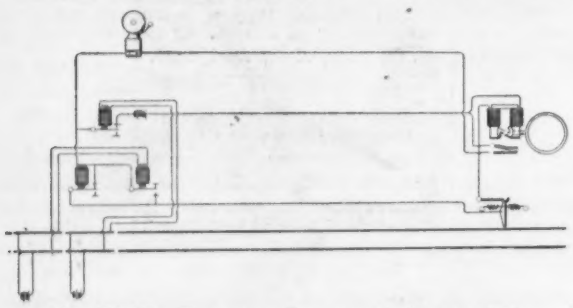
469,248. Electric Conductor for Metallic Circuits; Silas W. Holman, of Newton, Mass. Application filed Oct. 10, 1891. A metallic circuit electric conductor in which the out and return wires of each circuit constitute a pair and are arranged spirally in tubular form, leaving an air space within, the two wires of each pair being located diametrically opposite to one another throughout the length of such tube, and provided with supporting material to hold them in place.

469,253. Automatic Disconnector; Andrew Langstaff Johnston, of Richmond, Va. Application filed Sept. 10, 1891. In an automatic disconnector for overhead conductors, the combination, with the body thereof, provided with an insulated cap having jaws, of switch-bars mounted on the body of the disconnector, having heads at their upper ends, said heads being adapted to be thrown out of engagement when the wires are slackened.

469,257. Speed Regulator for Dynamos or Motors; Luther H. Leber, of Pittsburgh, Pa., Assignor to David J. Richardson, of same place. Application filed May 11, 1891. An automatic electrically controlled speed regulator for dynamos and motors, consisting of a governor having its centre rod insulated for a portion of its length, a main line wire having connection with a suitable battery and having contact, respectively, with the governor rod at a point thereof below the insulated portion, and with a binding post on the motor, a continuous wire connected, respectively, with a binding post on the motor and with a ring or disc carried by the lower portion of the governor arm, and gearing connecting the motor-shaft and the governor rod.

469,266. Electrical Burglar Alarm for Windows; Friend C. Page, of Creston, Ia. Application filed June 16, 1891. The invention consists in the combination with a metal plate extended across the top of a window sash of a series of leaf springs attached to the top of a window sash and wires entending across said frame, connected with the leaf springs as required to complete the circuit through the springs when the wires are either moved laterally or severed, an attachment to be placed on the side of a window sash adapted to complete a circuit when the sash is raised and to provide a continuity of electrical conductors to the top of the sash when the sash is either in a closed or partly opened position.

469,273. Electric Telegraph Apparatus; Joseph Robinson, of London, England. Application filed Jan. 21, 1891. In an electric telegraph transmitting and indicating apparatus, the combination of mechanism consisting of a transmitter hand lever rotating round the centre of an order plate, a spiral spring about



No. 469,438.—Railway Signaling Apparatus.

the axis of rotation, both ends of which meet with special set tension upon the frame of a first motion wheel, and also upon the driving-pin of the said hand lever, a train of wheels with controlling-flier, and a triple-drum commutator driven by said first motion driving wheel, a constant current closing device and locking lever, three electromagnets with pivoted armatures on a recording plate fed successively with intermittent currents from a constant current by the said rotated commutator and brushes rubbing thereon, a step-by-step recording mechanism consisting of a start-wheel rotated in either direction by successive intermittent action of said pivoted armatures, and pins attached thereto to operate a recording pointer in a similar direction to, and to the same extent as, the motion of the order transmitting hand lever.

469,280. Electric Railway; William Stuart Smith, of Berkeley, Cal. Application filed Sept. 3, 1891. The combination with a trolley arm, of a frame supporting the same, gearing for swinging the trolley arm about a vertical pivot, and a shaft for operating said gearing provided with a handle for the motor man. (See illustration).

469,281. Dynamo-Electric Machine; Johannes Sohlman, of Frederikshamn, Finland, Russia. Application filed Sept. 18, 1891. The combination, with two stationary annular armatures provided with induction coils, of a central shaft and two groups of field magnet poles carried by the shaft and adapted to be revolved within the two armatures, the pairs of armatures and groups having an equal number of poles and the position of the corresponding elements of the pairs being adjustable relative to each other. (See illustration).

469,283. Electric Hose Coupling; Joseph B. Strauss, of Cincinnati, O. Application filed Sept. 14, 1891. In combination with a hose coupling including outer and inner members insulated from each other by non-conducting cylinders, a flexible tube inclosing a pair of insulated wires and an expansion ring having a pair of slots with which slots said tube is engaged.

469,319. Commutator-Cleaning Device; William J. Phelps, of Elmwood, Ill. Application filed Feb. 7, 1891. In a commutator-cleaning device, the combination of a cleaning ribbon with a buffer to force the same against the commutator, and means for operating the buffer, whereby it may be controlled from the end or ends of the car.

469,347. Electric Arc Lamp; William D. Grave, of Cleveland, O. Application filed Nov. 9, 1891. An arc lamp comprising an upper carbon holder, a magnet in a shunt circuit and operating an armature having acorn projections, a lens having an open hinged ring gripping the carbon holder and a rod connecting said lever and armature.

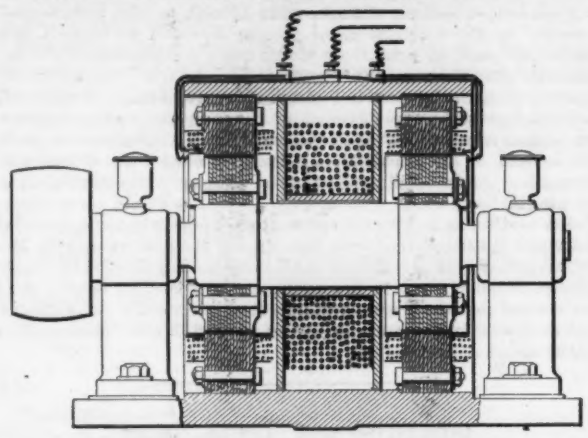
469,349. Poison Cabinet; Edmond George Kubler, of Akron, O. Application filed Dec. 14, 1891. A poison cabinet containing a number of bottle seats of different configuration, each provided with a circuit breaker arranged to operate an alarm bell when closed, and bottles having bases conforming to fit only their respective seats and open said circuit breaker when properly placed.

469,353. Overhead Conductor for Electric Railways; Edward M. Bentley, of New York. Application filed Sept. 17, 1887. In an electric railway, the combination of two suspended conductors supported from below, contact devices, each having a connection to the car, extending down beside the conductor upon which it bears, branch conductors adapted to the same contact devices, and a support for one of the lower conductors extending down from above the upper conductor on the side opposite the connection to the car.

469,361. Electric Elevator; Robert Watson, of Brooklyn, N. Y. Application filed Oct. 3, 1891. The combination, with an electric motor and a load connected to be moved thereby, of a governor arranged to increase or decrease the speed of the motor as the load is decreased or increased, respectively, said governor being automatically controlled by said load.

469,362. Electric Arc Lamp; Frederick Richard Boardman of Manor Park, England. Application filed Jan. 27, 1891. In incandescent arc lamps, the combination of a circular three-way refractory block, a metallic case or box therefor, two carbon electrodes seated in the said block, a tubular case for each electrode, insulated from the aforesaid box, and means for pressing the electrodes against the refractory block.

469,376. Fire Alarm System; Harvey Redding, of Everett, Assignor to the Redding Electric Company, of Boston, Mass. Application filed May 15, 1891. In a fire alarm system, the combination, with the alarm circuit, including a series of gongs, switches, a circuit breaking and closing wheel, a train to rotate said wheel, and an electromagnet to release and arrest the train, a branch or loop connected with the said circuit and having a circuit closing and breaking device, the latter including a movable rod or slide, which when in one position breaks the continuity of the said branch, leaving the system operative in the usual way, and when in another position closes the circuit and limits the movement of the wheel, whereby the gong may be tested by closing and breaking the circuit without giving the usual alarm.



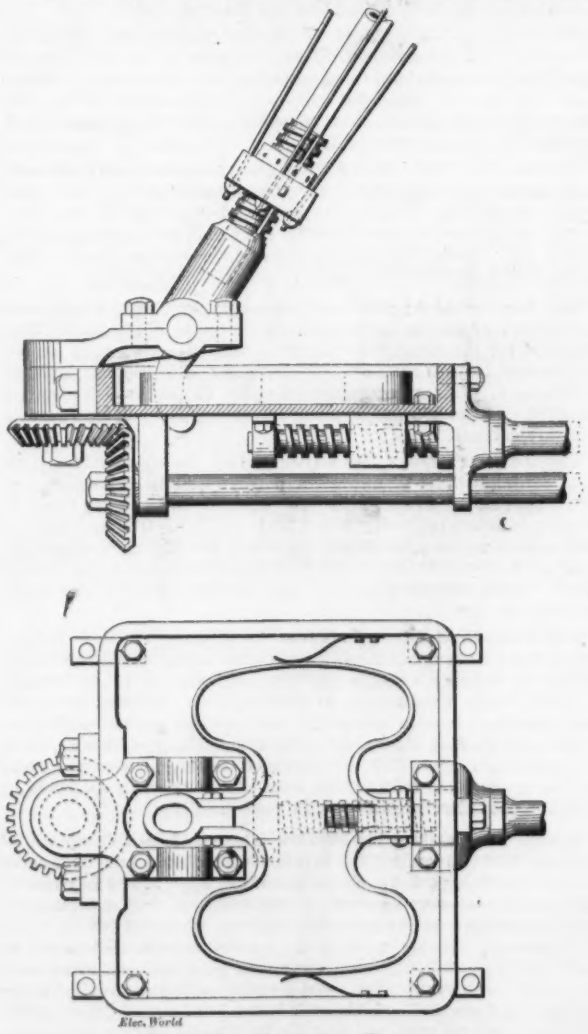
No. 469,281.—Dynamo Electric Machine.

469,408. Automatic Electric Gas-Lighting Burner; Rufus C. Nourse and Thomas W. Lane, of Boston, Mass., Assignors to the Electric Gas Lighting Company, of Portland, Me. Application filed Dec. 29, 1890. In an automatic electric gas-lighting burner, the combination, with two electric circuits and two corresponding short-circuiting devices, an electromagnet with two circuits, one helix in electrical connection with one circuit and the other with the other circuit, so that alternate series of vibrations of the armature may be made to operate the circuit breaker, which is at the burner tip, to there produce sparks when the gas is to be turned on and lighted to operate the circuit breaker, which is not at the tip when the gas is to be turned off.

469,424. Electrical and Low Water Alarm; Alcinus C. McConnel, of Allegheny, Pa. Application filed Dec. 2, 1890. In a steam generator, the combination of a float, a rock shaft operated by the rise and fall thereof, an electric circuit closer moving with the rock shaft, to which it is secured, and when deflected from a vertical position adapted to communicate with both poles of a battery, an electric signal operated on a closed circuit, and a cylindrical insulator sliding on the circuit closer adapted to be interposed between the points of contact.

469,428. Diaphragm for Electrical Cells; Charles N. Waite, of Newton, Mass. Application filed Feb. 18, 1891. A diaphragm for an electrical cell, consisting of a dense and compact layer, sheet, or film composed of a metallic albuminate.

469,438. Railway Signaling Apparatus; Frank I. Myers, of New York, assignor to the Hall Signal Company, of Maine. Application filed July 9, 1891. In an electric railway block signaling apparatus, a normally closed wire signaling circuit operating or controlling a signal guarding a block, the said circuit adapted to be operated by a train on its entering the block, and having a circuit breaker in its normally closed main branch and a circuit maker in a normally open shunt branch, in combination with two local circuits, each including a short section of the rails at the end of the block and adapted to be acted upon in succession by the train, the first of said two local circuits operat-



Elec. World

No. 469,280.—Electric Railway.

ing upon the circuit breaker in the main branch of the signaling circuit and the second of said local circuits operating upon the circuit maker in the shunt branch first mentioned, whereby the signaling circuit is restored to its normally closed condition and the signal is cleared by the last wheels of the train leaving the first of the two short sections of the rails at the end of the block. (See illustration).

469,441. Electro-Magnetic Reciprocating Engine; Merle J. Wightman, of Scranton, Pa. Application filed Feb. 5, 1891. In an electro-magnetic reciprocating engine, an iron cylinder and an iron core fitting the bore of said cylinder, in combination with electric coils in grooves or recesses in the interior of the cylinder and the exterior of the core. (See illustration).

469,462. Automatic Draft-Regulator; Ira F. Beers and Frederic C. Beers, of Elmira, N. Y. Application filed July 30, 1891. In a draft-regulator, the combination of a shaft rotably supported in a suitable frame, a pulley mounted thereon, a weighted cord wound on the pulley, an electromagnet, an armature, a scape projecting from the shaft and engaging the armature, a battery, a thermostat, a make-and-break device operated by the pulley, suitable electric connections between the battery, electromagnet, thermostat, and make-and-break device, and oppositely extending arms mounted upon said shaft and having connection with the dampers to be operated.

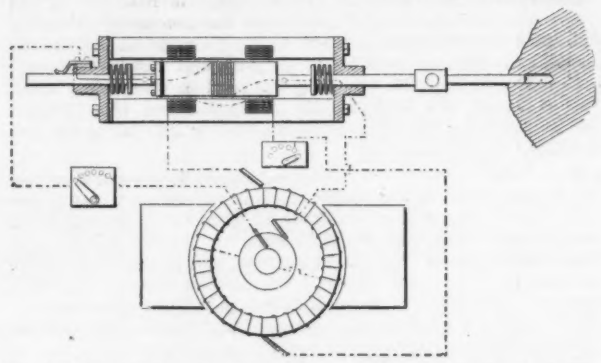
469,469. Tube for Electric Conductors; Edwin T. Greenfield, of New York, Assignor to the Interior Conduit and Insulation Company, of same place. Application filed March 21, 1891. The method of insulating concentric tubing, consisting in partially filling the outer tube with insulating material in liquid form, then inserting the inner tube, thereby causing the insulating material to fill the space between the two, and finally causing or allowing the insulating material to harden or set, whereby the tubes are firmly united together.

469,470. Conduit for Electric Conductors; Edwin T. Greenfield, of New York, Assignor to the Interior Conduit and Insulation Company, of same place. Application filed Aug. 14, 1891. A pair of non-conducting tubes having their ends abutting against each other and surrounded by a non-conducting ring imbedded in a metallic collar or sleeve, the ends of which fit tightly over the ends of the adjoining tubes.

469,471. Electro-Magnetic Stop Motion for Steam Engines; Wm. W. Hailstone, of Long Island City, N. Y. Application filed June 2, 1891. The combination, with an engine cylinder, valves for the admission of the motive force thereto, valve-operating mechanism, and cams for disengaging the valve-operating mechanism from the valves at predetermined intervals, of a lever for controlling the position of the cams, a lever operating rod for operating the lever independently of the governor, and an electric circuit, including an electromagnet for actuating the lever, operating to throw the cams into position to prevent connection between the valve-operating mechanism and valves.

469,474. Telephone Support; Hammond V. Hayes, of Cambridge, Mass., Assignor to the American Bell Telephone Company, of Boston, Mass. Application filed June 22, 1891. The combination of an adjustable telephone supporting arm pivoted at its fixed end to a stationary bracket, a spring coiled around the pivot and exerting a constant elevating force on said arm, and a clamping nut for regulating the force of said spring.

469,475. Electric Cable; Hammond V. Hayes, of Cambridge, and John S. Stone, of Boston, Assignors to the American Bell Telephone Company, of Boston, Mass. Application filed Oct. 12, 1891. A cable section of a double line circuit, composed of two associated members representing, respectively, the sides of said circuit, each member consisting of two independent parallel con-



No. 469,441.—Electric Magnetic Reciprocating Engine.

ductors separated from one another by a layer of insulating material of high specific capacity and being insulated as a whole from its associated member by non-conducting material of low specific inductive capacity.

469,482. Incandescent Lamp; Frederic H. Manchester, of Providence, R. I. Application filed Nov. 4, 1891. The combination, with the insulating plate, of a centrally perforated stud and headed contact tube secured therein, a contact ring or plate secured to the surface of the insulating plate by ears passing through the perforations, and wires secured to the contacts of the shell having a contracted step and a lip adapted to be bent over the shoulder of the insulating plate to secure the plate in place.

469,483. Incandescent Lamp; Frederic H. Manchester, of Providence, R. I. Application filed Nov. 4, 1891. In an incandescent lamp, the combinations, with a base having corrugations and a lip, a porcelain insulating plate secured within the lip and having a side perforated and a central perforated boss, a metal cap covering the boss and secured in place by a flanged tube extending through the perforation, and wires adapted to connect the shell and cap with the lamp filament.

469,486. Apparatus for Pointing Carbon Pencils; Philo Moses, of Fremont, O. Application filed April 21, 1891. In a carbon-pointing machine, the combination, with two parallel surfaces, of a grinding surface or surfaces attached to one of the said parallel surfaces and endless belts passing between the parallel surfaces in opposite directions, one of the belts revolving more rapidly than the others.

469,515. Electric Machine; Michael Von Dolivo-Dobrowolsky, of Berlin, Germany, Assignor to the Allgemeine Electricitäts Gesellschaft, of same place. Application filed Aug. 3, 1891. The combination of three or more electric current receiving devices or sets of devices, such as described, connected together to form a closed circuit or circuits, other electric devices or sets of devices of the same kind, being alike in number to that of the former and severally connected at one terminal to equidistant points of the said closed circuit or circuits, line wires connected to the other terminals of the latter's devices or sets of devices, and means for producing in the line wires currents of relatively differing phase.

469,522. Electric Cable; Hammond V. Hayes, of Cambridge, Mass. Application filed Aug. 16, 1889. A metallic electric circuit in which the direct and return wires are combined spirally with insulating material in such manner that the thickness of the insulating material from the common axis of the spirals to the inner surface of the wires, which are separated by substantially the diameter of the spirals, is greater than its thickness on the exterior surfaces.

469,652. Automatic Advertising Apparatus; Wm. C. Jennings, of Camden, N. J., Assignor to the Jennings Machine Company, of New Jersey. Application filed May 20, 1891. The combination of a series of electrically actuated indicating devices, separate circuits for each of the said indicating devices, a source of electrical energy common to all of the circuits, a series of movable contact plates or surfaces having contacts arranged thereon, and connecting with the source of electrical energy, a reciprocating circuit-closing plate having a series of contacts respectively connected with the several circuits, including the indicating device, and movable to and from the contact plates or surfaces, and a power device for moving the series of contact plates or surfaces successively past and in contact with the circuit closing plate for energizing the electric indicators in different predetermined order.

469,656. Electric-Lighting System; James F. McElroy, of Albany, N. Y. Application filed June 4, 1891. The combination with a dynamo-electric generator operated by the motion of the train of a potential switch in the circuit of said dynamo, said switch being operated by the magnetic pull of the revolving armature on the field-magnets mechanically transmitted to said switch.

Copies of the specifications and drawings complete of any patent mentioned in this record—or of any other patent issued since 1886—can be had for 25 cents. Give date and number of patent desired and address The W. J. Johnston Co., Ltd., Times Building, N. Y.